ENOSH SCIENCE CENTER

Technical Report

Electrical Load Study, LV Distribution, AVR and Cable Sizing

46 FM Broadcast Sites

Prepared in the ENOSH technical-report format, based on the submitted engineering study and reformatted for executive review, design coordination, and preliminary implementation planning.

Project	National FM Broadcast Network - 46 Sites
Source Study Date	11 Feb 2026

Electrical Load Study, LV Distribution, AVR and Cable Sizing
46 FM Broadcast Sites

Prepared by: ENOSH Science Center – Engineering
Client: Prof. Ibrahim El Noshokaty
Date: 11 Feb 2026

Figure 1. Source document cover page used as the technical basis for this reformatted report.

Executive Summary

The submitted study evaluates preliminary low-voltage power distribution for 46 FM transmitter sites using standardized assumptions for three-phase supply, transmitter efficiency, cooling allowance, protection headroom, and AVR headroom. Across the portfolio, the electrical strategy is deliberately standardized: most sites adopt a 40 A 3P MCCB main incomer, a 4C x 10 mm² copper XLPE/SWA/PVC main feeder, 16 A single-phase branch breakers for individual transmitters, and a dedicated AVR sized to the essential transmission load. Only the highest-demand site, Mahlla, steps up to a 45 kVA AVR, a 63 A MCCB, and a 4C x 16 mm² main feeder. The resulting portfolio is easy to replicate, maintain, and phase-balance, but the study correctly notes that all selections remain preliminary until verified against WORLDCAST nameplate data, ambient temperature, installation method, and the available utility short-circuit level.



Figure 2. Portfolio key metrics derived from the all-sites master summary.

Portfolio total design demand **339.79 kW**	**Aggregate AVR selection (sum of site recommendations)** **575 kVA**
Most common redundancy arrangement **6+1 (22 sites)**	**Most common RF class** **2 kW (32 sites)**

1. Project Basis and Scope

The source engineering package defines a preliminary electrical design workflow for each FM broadcast site, including load breakdown, main incomer breaker and feeder recommendation, AVR sizing concept, branch breaker schedule, and preliminary branch-cable cross-sections. The study explicitly frames itself as a preliminary engineering assessment, not a final issued-for-construction design.

- Portfolio coverage: 46 FM transmitter sites assessed individually.
- Core deliverables per site: demand estimate, AVR concept, incomer breaker, cable sizing concept, and circuit schedule.
- Final validation required against manufacturer nameplate data, actual site ambient temperature, installation method, and utility prospective short-circuit current.
- Standardized electrical basis: 400/230 V, 50 Hz, 3-phase, TN-S, with PF = 0.95.
- Assumed engineering factors: AC-to-RF efficiency $\eta = 0.72$, cooling COP = 3.2, main protection headroom = 25%, AVR headroom = 25%.

2. Calculation Framework and Assumptions

The electrical model in the source study treats each site as a standardized transmission block composed of active transmitters, one standby transmitter, RF combiner and switching allowance, control and monitoring allowance, rack ventilation, technical-room lighting, service sockets, and an HVAC electrical allowance. Demand is then mapped into incomer current, AVR size, feeder size, and a coordinated branch-protection schedule.

```
RF per active transmitter: P_RF,unit = P_RF,total / N_active
AC input per transmitter: P_AC,unit = P_RF,unit / η
Transmitter demand: P_TX,demand = N_active x P_AC,unit
3-phase line current: I = P / (sqrt(3) x V_LL x PF)
1-phase branch current: I = P / (V_LN x PF)
AVR sizing: S_AVR = (P_installed / PF) x (1 + headroom)
Voltage drop model: ΔV = sqrt(3) x I x L x (R cosφ + X sinφ)
```

Parameter	Assumption / design note
Supply	400/230 V, 50 Hz, 3-phase, TN-S
Power factor	0.95
Transmitter efficiency	η = 0.72 (replace with actual WORLDCAST value)
Cooling allowance	COP = 3.2 (replace with selected HVAC data)
Protection rule	In ≥ Ib ; Iz ≥ In ; Icu ≥ Ik
Voltage-drop intent	Typically 3% feeders, 5% total

3. Portfolio Results and Trends

The all-sites master summary reveals a strong standardization pattern. The portfolio is dominated by 2 kW sites, followed by a smaller 5 kW class, with single high-power outliers at 10 kW and 15 kW. As a result, only four demand plateaus appear in the full dataset: 5.47 kW, 10.11 kW, 17.85 kW, and 25.58 kW.

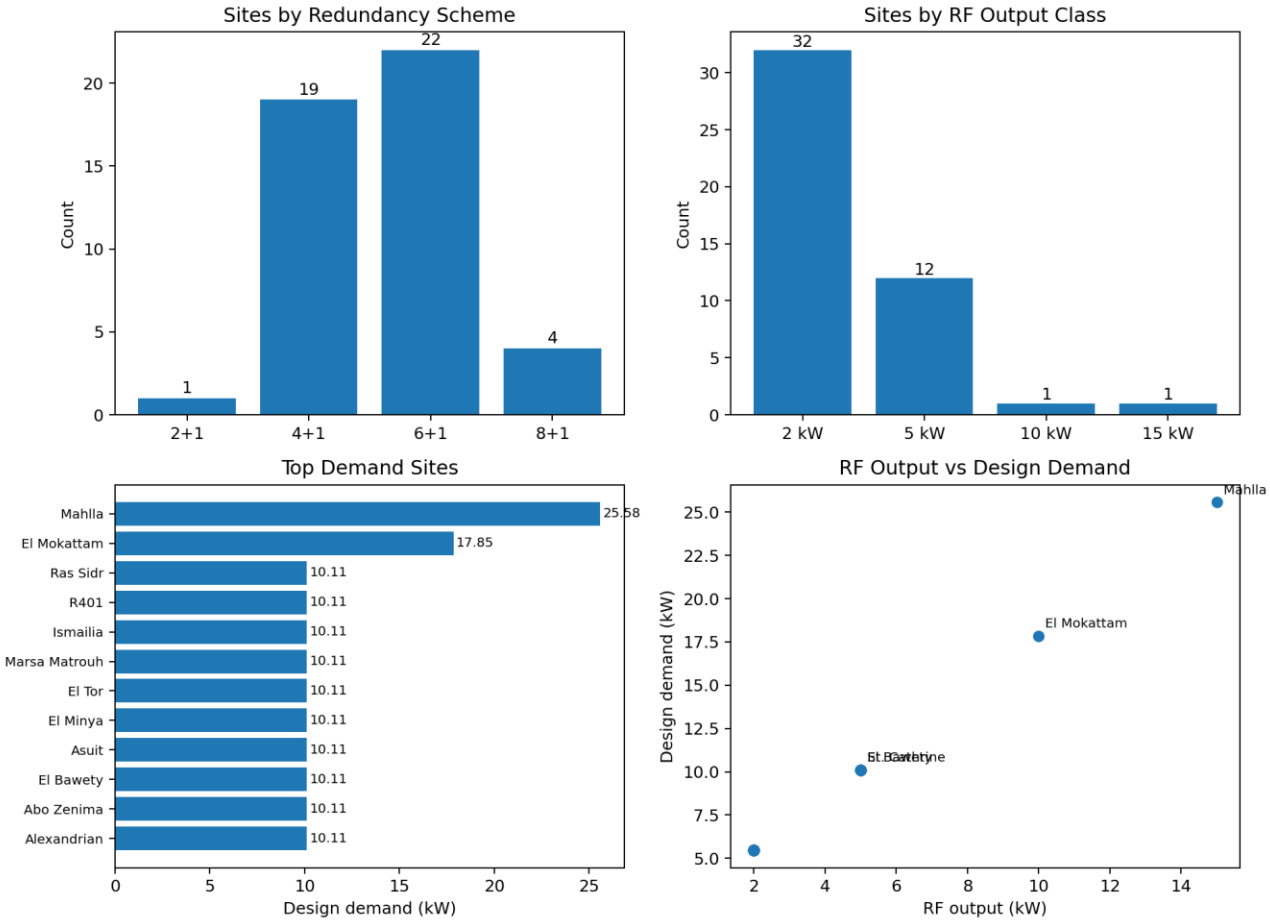

Figure 3. Distribution of redundancy schemes, RF output classes, top-demand sites, and RF output versus design demand.

Metric	Value / observation
46	Total sites in the submitted portfolio
32	Sites at 2 kW RF output
12	Sites at 5 kW RF output
1	Site at 10 kW RF output (El Mokattam)
1	Site at 15 kW RF output (Mahlla)
22	Sites configured as 6+1
19	Sites configured as 4+1
4	Sites configured as 8+1
1	Site configured as 2+1 (Port Said)
25.58 kW	Maximum site design demand
45 kVA	Maximum AVR recommendation
63 A	Maximum main incomer MCCB recommendation

4. Representative Design Classes

Although the source package contains 46 site sheets, the portfolio can be reduced to a small number of recurring design classes. This makes the report suitable for phased procurement and typology-based review.

Class	Observed schemes	Design demand (kW)	AVR (kVA)	Main MCCB (A)	Main feeder
2 kW - typical small/medium site	2+1 / 4+1 / 6+1	5.47	10	40	4C x 10 mm² Cu
5 kW - reinforced site	4+1 / 6+1 / 8+1	10.11	15	40	4C x 10 mm² Cu
10 kW - high-demand hub	8+1	17.85	30	40	4C x 10 mm² Cu
15 kW - highest-demand hub	8+1	25.58	45	63	4C x 16 mm² Cu

A notable engineering observation is that all 2 kW sites converge to the same 5.47 kW design demand regardless of whether the redundancy arrangement is 2+1, 4+1, or 6+1. This suggests that the submitted methodology is driven primarily by total RF output plus fixed non-transmitter allowances, rather than by the number of standby units alone.

5. Representative Source Visuals

To keep the reformatted technical report traceable to the submitted package, selected source pages are reproduced below. These figures show the original master-summary format and the recurring site-sheet structure used in the underlying engineering study.

1. Scope

Electrical load estimation and preliminary low-voltage distribution are conducted for 46 FM transmitter sites, assessed individually. Each site will receive the following deliverables: (1) a detailed load breakdown, (2) specifications for the main incomer breaker and cable, (3) AVR sizing and connection concept, (4) a circuit breaker schedule (MCB/MCCB/RCBO/isolators) with cut-off/interrupting considerations, and (5) relevant equations and standards references. This study serves as a preliminary engineering assessment. The final design must be validated against WORLDCAST nameplate data, measured site ambient temperature, installation method, and the utility's prospective short-circuit current.

2. Input Data

The input values taken into account include the redundancy configuration (2+1 / 4+1 / 6+1 / 8+1) and the total RF output power (W) for each site.

3. Master Summary (All Sites)

No.	Site	System	RF (W)	Design Demand (kW)	AVR (kVA)	Main MCCB (A)	Main Cable
01	Bani Suif	6+1	2000	5.47	10	40	4C x 10 mm² Cu XLPE/SWA/PVC (0.6/1 kV)
02	El Fayoum	6+1	2000	5.47	10	40	4C x 10 mm² Cu XLPE/SWA/PVC (0.6/1 kV)
03	El Minya	6+1	5000	10.11	15	40	4C x 10 mm² Cu XLPE/SWA/PVC (0.6/1 kV)
04	Asuit	6+1	5000	10.11	15	40	4C x 10 mm² Cu XLPE/SWA/PVC (0.6/1 kV)
05	Qina	6+1	2000	5.47	10	40	4C x 10 mm² Cu XLPE/SWA/PVC (0.6/1 kV)
06	Luxur	6+1	2000	5.47	10	40	4C x 10 mm² Cu XLPE/SWA/PVC (0.6/1 kV)
07	Isna	6+1	2000	5.47	10	40	4C x 10 mm² Cu XLPE/SWA/PVC (0.6/1 kV)

Figure 4. Source-page master summary excerpt showing the portfolio table structure and the first block of site recommendations.

6. Site-by-Site Design Sheets

Each site encompasses a load breakdown, AVR selection, a breaker schedule, and preliminary cable cross-sections.

Site 01 – Bani Suif

Input: System 6+1 (N active + 1 standby) ; RF output 2000 W.

Load item	Basis	kW	Notes
Transmitters (demand)	6 active × 0.46 kW	2.78	Standby TX excluded from demand
Combiner & RF switching	Fixed allowance	0.40	Verify with WORLDCAST combiner losses/PSU
Control/monitoring/network	Fixed allowance	0.20	Include monitoring PC/router
Rack ventilation / small fans	Fixed allowance	0.30	May be part of TX racks
Lighting	Small technical room	0.30	LED lighting
Service sockets	Diversity applied	0.50	General outlets, tools
HVAC electrical input	From losses, COP=3.2	0.99	Confirm A/C selection and starting
TOTAL design demand	Sum	5.47	Used for incomer sizing

Design element	Recommendation
AVR (TX + essential)	10 kVA, 3ϕ stabilizer, bypass + maintenance bypass
Main incomer current	8.3 A @ 400 V 3ϕ (PF=0.95)
Main breaker	40 A, 3P MCCB (IEC 60947-2), Icu≥Ik (utility)
Main feeder cable	4C x 10 mm² Cu XLPE/SWA/PVC (0.6/1 kV) (selected to match MCCB; final Iz check required)
Voltage drop check (example)	Assuming 50 m main feeder: ΔV≈1.3 V (0.32%) — replace 50 m by actual length
TX branch breaker (each TX)	16 A, 1P+N MCB curve C; local isolator
TX branch cable (each TX)	3C x 2.5 mm² Cu XLPE/LSZH (0.6/1 kV)

Breaker distribution schedule (MDB / TX-DB):

Circuit	Load	Poles	Device Std.	Rating	Trip/Curve	Disconnection	Cable	Remarks
IN-01	Utility incomer	3P	IEC 60947-2 MCCB	40 A	TM/adj.	Lockable isolator upstream	4C x 10 mm² Cu XLPE/SWA/PVC (0.6/1 kV)	Select Icu ≥ prospective Ik; add metering
SPD-01	Surge protection	3P	IEC 61643-11 SPD	As per fault level	Type 1+2	—	—	At service entrance

Figure 5. Original site sheet example for Bani Suif (6+1, 2 kW), including load breakdown, AVR recommendation, and breaker schedule.

Site 03 – El Minya

Input: System 6+1 (N active + 1 standby) ; RF output 5000 W.

Load item	Basis	kW	Notes
Transmitters (demand)	6 active × 1.16 kW	6.94	Standby TX excluded from demand
Combiner & RF switching	Fixed allowance	0.40	Verify with WORLDCAST combiner losses/PSU
Control/monitoring/network	Fixed allowance	0.20	Include monitoring PC/router
Rack ventilation / small fans	Fixed allowance	0.30	May be part of TX racks
Lighting	Small technical room	0.30	LED lighting
Service sockets	Diversity applied	0.50	General outlets, tools
HVAC electrical input	From losses, COP=3.2	1.47	Confirm A/C selection and starting
TOTAL design demand	Sum	10.11	Used for incomer sizing

Design element	Recommendation
AVR (TX + essential)	15 kVA, 3ϕ stabilizer, bypass + maintenance bypass
Main incomer current	15.4 A @ 400 V 3ϕ (PF=0.95)
Main breaker	40 A, 3P MCCB (IEC 60947-2), Icu≥Ik (utility)
Main feeder cable	4C x 10 mm² Cu XLPE/SWA/PVC (0.6/1 kV) (selected to match MCCB; final Iz check required)
Voltage drop check (example)	Assuming 50 m main feeder: ΔV≈2.3 V (0.59%) — replace 50 m by actual length
TX branch breaker (each TX)	16 A, 1P+N MCB curve C; local isolator
TX branch cable (each TX)	3C x 2.5 mm² Cu XLPE/LSZH (0.6/1 kV)

Breaker distribution schedule (MDB / TX-DB):

Circuit	Load	Poles	Device Std.	Rating	Trip/Curve	Disconnection	Cable	Remarks
IN-01	Utility incomer	3P	IEC 60947-2 MCCB	40 A	TM/adj.	Lockable isolator upstream	4C x 10 mm² Cu XLPE/SWA/PVC (0.6/1 kV)	Select Icu ≥ prospective Ik; add metering
SPD-01	Surge protection	3P	IEC 61643-11 SPD	As per fault level	Type 1+2	—	—	At service entrance
AVR-01	AVR input/output	3P	IEC 60947-3 switch	Sized with AVR	Manual bypass	Maintenance isolation	Internal	Servo/static stabilizer

Figure 6. Original site sheet example for El Minya (6+1, 5 kW), illustrating the higher-demand template within the same standardized framework.

6. Protection, Cabling, and Implementation Logic

The study follows a coherent low-voltage protection architecture aligned with common IEC practice for industrial and technical spaces. At the service entrance, a 3P MCCB protects the incomer and coordinates with a Type 1+2 surge protective device. An AVR is inserted with manual and maintenance bypass capability. Individual transmitters are distributed over phases via 1P+N MCBs, while RCBO devices are reserved for lighting, control/monitoring circuits, and service sockets. HVAC remains on a dedicated 3P breaker and local isolator.

Design topic	Interpretation in the submitted study
Main incomer	3P MCCB to IEC 60947-2, selected with Icu >= prospective Ik
Isolation	Local lockable isolators near transmitters; switchgear isolation to IEC 60947-3
Surge protection	Type 1+2 SPD at service entrance; Type 2 for sensitive downstream loads where required
Personnel protection	30 mA RCBO protection for lighting and socket circuits
Indoor cabling	LSZH recommended for indoor routes
Outdoor/underground cabling	SWA construction recommended
Earthing arrangement	TN-S with separate neutral and PE bars
Cable checks still required	Ambient correction, grouping, installation method, and voltage-drop verification

7. Engineering Discussion

From a portfolio-management perspective, the strongest aspect of the submitted study is repeatability. Standardized load blocks make it possible to batch procurement of MCCBs, SPDs, branch MCBs, RCBOs, AVRs, and common cable sizes. This reduces review friction and site-to-site design variance. The methodology also balances transmission continuity with maintainability by clearly separating essential transmission loads from ancillary loads.

At the same time, the study correctly remains conservative about final approval. Several parameters are placeholders that can materially shift the design: actual WORLDCAST transmitter input power, real HVAC starting current, measured site temperatures, cable installation method, feeder length, grouping factors, and the utility's short-circuit contribution. The repeated note to verify Icu, Iz, and voltage-drop performance before final issue is technically justified and should remain part of any issued design package.

Potential deviation	Likely electrical impact
Actual transmitter input power higher than estimate	Increase in demand, branch current, and AVR rating
High ambient temperature or grouped cables	Reduction in cable ampacity; possible cable upsizing
Higher HVAC start current than assumed	Need for larger breaker or different trip curve
Longer feeder routes than the 50 m example	Higher voltage drop; possible feeder upsizing
High utility fault level	Need for higher Icu / interrupting capacity

8. Technical Recommendations

- Freeze the final design only after confirming transmitter nameplate input power and cooling system electrical data for each site.
- Use the current report as a typology and procurement baseline, not as the final protective-device coordination study.
- Re-check main cable ampacity against actual routing, ambient temperature, grouping, and installation method before release.
- Confirm service short-circuit current at every utility interface and choose MCCB / SPD ratings accordingly.
- Keep power cabling, RF lines, and control cabling segregated in the final layout, with continuous bonding of racks and trays to PE.
- Where several sites share identical demand classes, prepare standard MDB / TX-DB schematics to reduce implementation time and improve quality control.

9. Conclusion

This reformatted technical report confirms that the source study presents a coherent preliminary low-voltage design strategy for a 46-site FM broadcast portfolio. The engineering logic is consistent across sites, the protection hierarchy is recognizable, the AVR selections scale rationally with design demand, and the branch-circuit philosophy is broadly standardized. The portfolio is therefore suitable for technical review, concept-level budgeting, and early procurement planning. Final approval, however, still depends on manufacturer validation, short-circuit confirmation, and field-specific cable and thermal checks.

References

1. ENOSH Science Center - Engineering. Electrical Load Study, LV Distribution, AVR and Cable Sizing, 46 FM Broadcast Sites. Source study dated 11 Feb 2026.
2. IEC 60364-1:2025. Low-voltage electrical installations - Part 1: Fundamental principles, assessment of general characteristics, and definitions. International Electrotechnical Commission.
3. IEC 61439-1:2020. Low-voltage switchgear and controlgear assemblies - Part 1: General rules. International Electrotechnical Commission.
4. IEC 60947-2. Low-voltage switchgear and controlgear - Circuit-breakers. International Electrotechnical Commission.
5. IEC 60947-3. Low-voltage switchgear and controlgear - Switches, disconnectors, switch-disconnectors and fuse-combination units. International Electrotechnical Commission.
6. IEC 60898-1. Electrical accessories - Circuit-breakers for overcurrent protection for household and similar installations. International Electrotechnical Commission.
7. IEC 60502-1 and IEC 60228. Power cables with extruded insulation and rated voltages from 1 kV up to 30 kV, and conductors of insulated cables. International Electrotechnical Commission.
8. IEC 61643-11:2025. Low-voltage surge protective devices - Part 11: Surge protective devices connected to AC low-voltage power systems. International Electrotechnical Commission.
9. NFPA 70 (2026). National Electrical Code. National Fire Protection Association.
10. Manufacturer data and final equipment catalogues for WORLDCAST transmitters, AVRs, HVAC systems, and low-voltage protective devices should govern final equipment selection.

Appendix A - All-Sites Master Summary

The following appendix rebuilds the master summary from the submitted portfolio study into a single readable table for cross-site comparison.

No.	Site	System	RF (kW)	Demand (kW)	AVR (kVA)	MCCB (A)	Main cable
1	Bani Suif	6+1	2	5.47	10	40	4C x 10 mm² Cu XLPE/SWA/PVC (0.6/1 kV)
2	El Fayoum	6+1	2	5.47	10	40	4C x 10 mm² Cu XLPE/SWA/PVC (0.6/1 kV)
3	El Minya	6+1	5	10.11	15	40	4C x 10 mm² Cu XLPE/SWA/PVC (0.6/1 kV)
4	Asuit	6+1	5	10.11	15	40	4C x 10 mm² Cu XLPE/SWA/PVC (0.6/1 kV)
5	Qina	6+1	2	5.47	10	40	4C x 10 mm² Cu XLPE/SWA/PVC (0.6/1 kV)
6	Luxur	6+1	2	5.47	10	40	4C x 10 mm² Cu XLPE/SWA/PVC (0.6/1 kV)
7	Isna	6+1	2	5.47	10	40	4C x 10 mm² Cu XLPE/SWA/PVC (0.6/1 kV)
8	Idfu	6+1	2	5.47	10	40	4C x 10 mm² Cu XLPE/SWA/PVC (0.6/1 kV)
9	Kom Ombo	6+1	2	5.47	10	40	4C x 10 mm² Cu XLPE/SWA/PVC (0.6/1 kV)
10	Aswan	6+1	2	5.47	10	40	4C x 10 mm² Cu XLPE/SWA/PVC (0.6/1 kV)
11	Abu simble	6+1	2	5.47	10	40	4C x 10 mm² Cu XLPE/SWA/PVC (0.6/1 kV)
12	El Kharga	4+1	2	5.47	10	40	4C x 10 mm² Cu XLPE/SWA/PVC (0.6/1 kV)
13	ElDakhla	4+1	2	5.47	10	40	4C x 10 mm² Cu XLPE/SWA/PVC (0.6/1 kV)
14	EL BAWETY	4+1	5	10.11	15	40	4C x 10 mm² Cu XLPE/SWA/PVC (0.6/1 kV)
15	EL MOKATTAM	8+1	10	17.85	30	40	4C x 10 mm² Cu XLPE/SWA/PVC (0.6/1 kV)
16	R401	8+1	5	10.11	15	40	4C x 10 mm² Cu XLPE/SWA/PVC (0.6/1 kV)
17	Wadi El natron	4+1	2	5.47	10	40	4C x 10 mm² Cu XLPE/SWA/PVC (0.6/1 kV)
18	R8	4+1	2	5.47	10	40	4C x 10 mm² Cu XLPE/SWA/PVC (0.6/1 kV)
19	Abo homos	4+1	2	5.47	10	40	4C x 10 mm² Cu XLPE/SWA/PVC (0.6/1 kV)
20	Hamam	4+1	2	5.47	10	40	4C x 10 mm² Cu XLPE/SWA/PVC (0.6/1 kV)
21	El Alameen	4+1	2	5.47	10	40	4C x 10 mm² Cu XLPE/SWA/PVC (0.6/1 kV)
22	El Dabaa	4+1	2	5.47	10	40	4C x 10 mm² Cu XLPE/SWA/PVC (0.6/1 kV)

No.	Site	System	RF (kW)	Demand (kW)	AVR (kVA)	MCCB (A)	Main cable
23	Ras El Hekma	4+1	2	5.47	10	40	4C x 10 mm² Cu XLPE/SWA/PVC (0.6/1 kV)
24	Marsa Matrouh	6+1	5	10.11	15	40	4C x 10 mm² Cu XLPE/SWA/PVC (0.6/1 kV)
25	Sidi Barany	4+1	2	5.47	10	40	4C x 10 mm² Cu XLPE/SWA/PVC (0.6/1 kV)
26	El Salum	4+1	2	5.47	10	40	4C x 10 mm² Cu XLPE/SWA/PVC (0.6/1 kV)
27	Dymiat	4+1	2	5.47	10	40	4C x 10 mm² Cu XLPE/SWA/PVC (0.6/1 kV)
28	Port Said	2+1	2	5.47	10	40	4C x 10 mm² Cu XLPE/SWA/PVC (0.6/1 kV)
29	Ismailia	6+1	5	10.11	15	40	4C x 10 mm² Cu XLPE/SWA/PVC (0.6/1 kV)
30	Suez	6+1	2	5.47	10	40	4C x 10 mm² Cu XLPE/SWA/PVC (0.6/1 kV)
31	Ras Sidr	4+1	5	10.11	15	40	4C x 10 mm² Cu XLPE/SWA/PVC (0.6/1 kV)
32	Abo Zenima	4+1	5	10.11	15	40	4C x 10 mm² Cu XLPE/SWA/PVC (0.6/1 kV)
33	El Tor	6+1	5	10.11	15	40	4C x 10 mm² Cu XLPE/SWA/PVC (0.6/1 kV)
34	Sharm El shikh	6+1	5	10.11	15	40	4C x 10 mm² Cu XLPE/SWA/PVC (0.6/1 kV)
35	Dahab	4+1	2	5.47	10	40	4C x 10 mm² Cu XLPE/SWA/PVC (0.6/1 kV)
36	Nwibaa	4+1	2	5.47	10	40	4C x 10 mm² Cu XLPE/SWA/PVC (0.6/1 kV)
37	Taba	4+1	2	5.47	10	40	4C x 10 mm² Cu XLPE/SWA/PVC (0.6/1 kV)
38	St. Cathrine	6+1	5	10.11	15	40	4C x 10 mm² Cu XLPE/SWA/PVC (0.6/1 kV)
39	Ras Ghareb	6+1	2	5.47	10	40	4C x 10 mm² Cu XLPE/SWA/PVC (0.6/1 kV)
40	Hurghada	6+1	2	5.47	10	40	4C x 10 mm² Cu XLPE/SWA/PVC (0.6/1 kV)
41	Safaga	6+1	2	5.47	10	40	4C x 10 mm² Cu XLPE/SWA/PVC (0.6/1 kV)
42	Qusir	6+1	2	5.47	10	40	4C x 10 mm² Cu XLPE/SWA/PVC (0.6/1 kV)
43	Masa Alam	6+1	2	5.47	10	40	4C x 10 mm² Cu XLPE/SWA/PVC (0.6/1 kV)
44	Mahlla	8+1	15	25.58	45	63	4C x 16 mm² Cu XLPE/SWA/PVC (0.6/1 kV)
45	Alexandrian	8+1	5	10.11	15	40	4C x 10 mm² Cu XLPE/SWA/PVC (0.6/1 kV)
46	Siwa	4+1	2	5.47	10	40	4C x 10 mm² Cu XLPE/SWA/PVC (0.6/1 kV)