

TABLE I: Optimized irregular source and relay constellations obtained from $\mathbf{P0}$ for EVM = -15 dB.

| | $\bar{\gamma} = 15$ dB | $\bar{\gamma} = 20$ dB | $\bar{\gamma} = 25$ dB | $\bar{\gamma} = 30$ dB | $\bar{\gamma} = 35$ dB | $\bar{\gamma} = 40$ dB | 16-QAM |
|----------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|-----------------|
| s_1 | 0.2295+0.0140i | 0.5703+0.1592i | 0.5738+0.1602i | 0.5739+0.1602i | 0.5737+0.1602i | 0.5736+0.1601i | 0.3162+0.3162i |
| s_2 | 0.6280+0.3797i | 0.9695+0.7175i | 0.9675+0.7181i | 0.9675+0.7182i | 0.9675+0.7181i | 0.9675+0.7181i | 0.3162+0.9487i |
| s_3 | 1.2789+0.1547i | 1.2010-0.1117i | 1.1995-0.1132i | 1.1995-0.1133i | 1.1995-0.1132i | 1.1996-0.1132i | 0.9487+0.3162i |
| s_4 | 0.6479+1.0925i | 0.3227+1.2564i | 0.3225+1.2558i | 0.3225+1.2558i | 0.3225+1.2559i | 0.3225+1.2559i | 0.9487+0.9487i |
| s_5 | -0.0175-0.5691i | -0.1473-0.5736i | -0.1482-0.5770i | -0.1482-0.5772i | -0.1482-0.5769i | -0.1481-0.5768i | 0.3162-0.3162i |
| s_6 | 0.2734-1.1913i | 0.1367-1.1984i | 0.1382-1.1969i | 0.1383-1.1969i | 0.1382-1.1969i | 0.1381-1.1970i | 0.3162-0.9487i |
| s_7 | 0.5996-0.3542i | 0.4464-0.4372i | 0.4483-0.4391i | 0.4484-0.4392i | 0.4483-0.4391i | 0.4483-0.4391i | 0.9487-0.3162i |
| s_8 | 1.0915-0.8008i | 0.9267-0.9076i | 0.9263-0.9072i | 0.9263-0.9072i | 0.9264-0.9073i | 0.9264-0.9073i | 0.9487-0.9487i |
| s_9 | 0.0175+0.5691i | 0.1554+0.6052i | 0.1561+0.6078i | 0.1561+0.6079i | 0.1561+0.6078i | 0.1561+0.6078i | -0.3162+0.3162i |
| s_{10} | -0.2734+1.1913i | -0.5038+1.0959i | -0.5017+1.0954i | -0.5016+1.0954i | -0.5017+1.0954i | -0.5018+1.0955i | -0.3162+0.9487i |
| s_{11} | -0.5996+0.3542i | -0.4231+0.4143i | -0.4256+0.4168i | -0.4257+0.4169i | -0.4256+0.4168i | -0.4255+0.4167i | -0.9487+0.3162i |
| s_{12} | -1.0915+0.8008i | -1.1062+0.4809i | -1.1057+0.4788i | -1.1056+0.4787i | -1.1057+0.4788i | -1.1057+0.4788i | -0.9487+0.9487i |
| s_{13} | -0.2295-0.0140i | -0.0000-0.0000i | -0.0000-0.0000i | -0.0000-0.0000i | -0.0000-0.0000i | -0.0000-0.0000i | -0.3162-0.3162i |
| s_{14} | -0.6280-0.3797i | -0.6018-0.1680i | -0.6044-0.1687i | -0.6046-0.1688i | -0.6044-0.1687i | -0.6044-0.1687i | -0.3162-0.9487i |
| s_{15} | -1.2789-0.1547i | -1.2494-0.3488i | -1.2489-0.3486i | -1.2488-0.3486i | -1.2489-0.3486i | -1.2489-0.3486i | -0.9487-0.3162i |
| s_{16} | -0.6479-1.0925i | -0.6972-0.9843i | -0.6978-0.9822i | -0.6979-0.9821i | -0.6978-0.9822i | -0.6978-0.9823i | -0.9487-0.9487i |

TABLE II: Optimized irregular source and relay constellations obtained from $\mathbf{P0}$ for EVM = -20 dB.

| | $\bar{\gamma} = 10$ dB | $\bar{\gamma} = 15$ dB | $\bar{\gamma} = 20$ dB | $\bar{\gamma} = 25$ dB | $\bar{\gamma} = 30$ dB | $\bar{\gamma} = 35$ dB | $\bar{\gamma} = 40$ dB |
|----------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|
| s_1 | 0.5759-0.0054i | 0.5926-0.1536i | 0.6103-0.1621i | 0.6174-0.1536i | 0.0963+0.1285i | -0.0117+0.0088i | -0.0025+0.0001i |
| s_2 | 0.3053+0.5170i | 0.3735+0.3945i | 0.4242+0.4260i | 0.4220+0.4378i | 0.3087+0.7102i | 0.2361+0.5827i | 0.2686+0.5556i |
| s_3 | 1.2676+0.3034i | 1.1096+0.4915i | 1.1003+0.4872i | 1.0891+0.5042i | 0.7197+0.2308i | 0.6208+0.0742i | 0.6390+0.0460i |
| s_4 | 0.7303+1.1304i | 0.5145+1.0433i | 0.4851+1.1010i | 0.4576+1.1073i | 0.9637+0.9137i | 0.8814+0.7807i | 0.8845+0.8042i |
| s_5 | 0.0421-0.1554i | 0.1372-0.5439i | 0.1563-0.5793i | 0.1690-0.5870i | 0.4255-0.3464i | 0.3547-0.4895i | 0.3424-0.5105i |
| s_6 | 0.2575-1.2842i | -0.0785-1.1987i | -0.1267-1.1956i | -0.1101-1.1960i | 0.1279-1.2078i | 0.2680-1.1547i | 0.2609-1.1686i |
| s_7 | 0.3235-0.5343i | 0.7164-0.9525i | 0.7098-0.9711i | -0.7342-0.9482i | 1.2320-0.2380i | 1.2759+0.0511i | 1.2923+0.0921i |
| s_8 | 1.1068-0.6816i | 1.2653-0.3247i | 1.2523-0.3354i | 1.2575-0.3074i | 0.7718-0.8818i | 0.9777-0.6891i | 0.9859-0.6693i |
| s_9 | -0.0713+0.1659i | -0.0256+0.0011i | 0.0003+0.0007i | -0.0016-0.0007i | -0.3469+0.5496i | -0.3920+0.5252i | -0.3613+0.5311i |
| s_{10} | -0.2510+1.2820i | -0.2836+1.2780i | -0.3387+1.2515i | -0.3574+1.2446i | -0.0970+1.2447i | 0.1235+1.2340i | 0.0882+1.1942i |
| s_{11} | -0.3269+0.5463i | -0.1820+0.5983i | -0.1644+0.6101i | -0.1779+0.6112i | -1.0604+0.2338i | -1.1361+0.3629i | -1.1377+0.3663i |
| s_{12} | -1.1063+0.6770i | -0.9796+0.7408i | -0.9726+0.7074i | -0.9775+0.6943i | -0.8887+0.9374i | -0.6994+1.0887i | -0.7219+1.0761i |
| s_{13} | -0.5610-0.0070i | -0.5909+0.1582i | -0.5799+0.1556i | -0.5926+0.1458i | -0.4848-0.0666i | -0.6213-0.0669i | -0.6181-0.0448i |
| s_{14} | -0.3008-0.5413i | -0.4610-0.4313i | -0.4458-0.4469i | -0.4414-0.4606i | -0.1641-0.5780i | -0.2645-0.5849i | -0.2827-0.5771i |
| s_{15} | -1.2462-0.2911i | -1.2172-0.1313i | -1.1950-0.1312i | -1.1898-0.1576i | -1.0162-0.5149i | -1.0730-0.5448i | -1.0775-0.5265i |
| s_{16} | -0.7455-1.1217i | -0.8908-0.9698i | -0.9154-0.9178i | -0.8986-0.9343i | -0.5874-1.1151i | -0.5401-1.1784i | -0.5600-1.1690i |

TABLE III: Optimized irregular source and relay constellations obtained from $\mathbf{P0}$ for EVM = -30 dB.

| | $\bar{\gamma} = 15$ dB | $\bar{\gamma} = 20$ dB | $\bar{\gamma} = 25$ dB | $\bar{\gamma} = 30$ dB | $\bar{\gamma} = 35$ dB | $\bar{\gamma} = 40$ dB | 16-QAM |
|----------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|-----------------|
| s_1 | 0.3496+0.5088i | 0.3578+0.5196i | 0.3601+0.5230i | 0.3608+0.5240i | 0.3610+0.5243i | 0.3610+0.5243i | 0.3162+0.3162i |
| s_2 | -0.0997+1.2047i | -0.0912+1.1997i | -0.0872+1.1977i | -0.0857+1.1971i | -0.0853+1.1969i | -0.0852+1.1969i | 0.3162+0.9487i |
| s_3 | 1.1617+0.3369i | 1.1533+0.3429i | 1.1500+0.3459i | 1.1489+0.3471i | 1.1486+0.3474i | 1.1485+0.3475i | 0.9487+0.3162i |
| s_4 | 0.7371+1.0706i | 0.7350+1.0675i | 0.7347+1.0671i | 0.7346+1.0670i | 0.7346+1.0670i | 0.7346+1.0670i | 0.9487+0.9487i |
| s_5 | 0.5801-0.0455i | 0.5983-0.0476i | 0.6042-0.0481i | 0.6060-0.0482i | 0.6066-0.0482i | 0.6067-0.0483i | 0.3162-0.3162i |
| s_6 | 0.2658-0.5573i | 0.2711-0.5697i | 0.2729-0.5733i | 0.2734-0.5744i | 0.2735-0.5747i | 0.2736-0.5748i | 0.3162-0.9487i |
| s_7 | 1.0934-0.5165i | 1.0846-0.5209i | 1.0809-0.5234i | 1.0796-0.5243i | 1.0792-0.5246i | 1.0791-0.5247i | 0.9487-0.3162i |
| s_8 | 0.5580-1.1734i | 0.5570-1.1703i | 0.5568-1.1698i | 0.5567-1.1697i | 0.5567-1.1697i | 0.5567-1.1697i | 0.9487-0.9487i |
| s_9 | 0.0003-0.0001i | -0.0000-0.0000i | -0.0000-0.0000i | -0.0000-0.0000i | -0.0000-0.0000i | -0.0000-0.0000i | -0.3162+0.3162i |
| s_{10} | -0.2505+0.5249i | -0.2580+0.5420i | -0.2605+0.5473i | -0.2613+0.5489i | -0.2615+0.5494i | -0.2616+0.5496i | -0.3162+0.9487i |
| s_{11} | -1.2953+0.1034i | -1.2920+0.1027i | -1.2915+0.1027i | -1.2914+0.1027i | -1.2913+0.1027i | -1.2913+0.1027i | -0.9487+0.3162i |
| s_{12} | -0.8727+0.8375i | -0.8736+0.8273i | -0.8746+0.8230i | -0.8750+0.8214i | -0.8752+0.8210i | -0.8752+0.8208i | -0.9487+0.9487i |
| s_{13} | -0.3295-0.4794i | -0.3404-0.4944i | -0.3437-0.4992i | -0.3448-0.5008i | -0.3451-0.5012i | -0.3452-0.5013i | -0.3162-0.3162i |
| s_{14} | -0.2892-1.1746i | -0.2797-1.1702i | -0.2754-1.1689i | -0.2739-1.1685i | -0.2734-1.1684i | -0.2733-1.1684i | -0.3162-0.9487i |
| s_{15} | -0.6152+0.0485i | -0.6289+0.0500i | -0.6330+0.0503i | -0.6342+0.0504i | -0.6345+0.0505i | -0.6346+0.0505i | -0.9487-0.3162i |
| s_{16} | -0.9941-0.6885i | -0.9934-0.6788i | -0.9937-0.6744i | -0.9939-0.6728i | -0.9939-0.6723i | -0.9939-0.6722i | -0.9487-0.9487i |

TABLE IV: Optimized irregular source and relay constellations obtained from $\mathbf{P0}$ for EVM = $-\infty$ dB.

| | $\bar{\gamma} = 15$ dB | $\bar{\gamma} = 20$ dB | $\bar{\gamma} = 25$ dB | $\bar{\gamma} = 30$ dB | $\bar{\gamma} = 35$ dB | $\bar{\gamma} = 40$ dB | 16-QAM |
|----------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|-----------------|
| s_1 | -0.0000-0.0000i | -0.0000-0.0000i | -0.0000-0.0000i | -0.0000-0.0000i | -0.0000-0.0000i | -0.0000-0.0000i | 0.3162+0.3162i |
| s_2 | 0.4208+0.4516i | 0.4302+0.4617i | 0.4329+0.4647i | 0.4338+0.4656i | 0.4340+0.4659i | 0.4341+0.4659i | 0.3162+0.9487i |
| s_3 | 1.1984+0.1633i | 1.1910+0.1703i | 1.1882+0.1738i | 1.1872+0.1751i | 1.1869+0.1756i | 1.1869+0.1756i | 0.9487+0.3162i |
| s_4 | 0.8855+0.9505i | 0.8835+0.9483i | 0.8831+0.9479i | 0.8830+0.9478i | 0.8830+0.9478i | 0.8830+0.9478i | 0.9487+0.9487i |
| s_5 | 0.1807-0.5902i | 0.1848-0.6034i | 0.1860-0.6073i | 0.1863-0.6084i | 0.1864-0.6088i | 0.1864-0.6089i | 0.3162-0.3162i |
| s_6 | 0.3804-1.2422i | 0.3795-1.2392i | 0.3793-1.2388i | 0.3793-1.2386i | 0.3793-1.2386i | 0.3793-1.2386i | 0.3162-0.9487i |
| s_7 | 0.5673-0.1307i | 0.5851-0.1348i | 0.5908-0.1361i | 0.5927-0.1366i | 0.5933-0.1367i | 0.5934-0.1367i | 0.9487-0.3162i |
| s_8 | 1.0062-0.6712i | 0.9964-0.6743i | 0.9923-0.6762i | 0.9909-0.6770i | 0.9904-0.6773i | 0.9904-0.6773i | 0.9487-0.9487i |
| s_9 | -0.1704+0.5566i | -0.1758+0.5741i | -0.1775+0.5797i | -0.1781+0.5816i | -0.1783+0.5822i | -0.1783+0.5822i | -0.3162+0.3162i |
| s_{10} | 0.0782+1.2070i | 0.0857+1.2000i | 0.0894+1.1975i | 0.0908+1.1966i | 0.0913+1.1963i | 0.0913+1.1963i | -0.3162+0.9487i |
| s_{11} | -1.2659+0.2917i | -1.2630+0.2910i | -1.2625+0.2909i | -1.2623+0.2908i | -1.2623+0.2908i | -1.2623+0.2908i | -0.9487+0.3162i |
| s_{12} | -0.7406+0.9562i | -0.7430+0.9463i | -0.7446+0.9421i | -0.7453+0.9406i | -0.7455+0.9401i | -0.7455+0.9401i | -0.9487+0.9487i |
| s_{13} | -0.6015+0.1386i | -0.6149+0.1417i | -0.6189+0.1426i | -0.6201+0.1429i | -0.6205+0.1429i | -0.6205+0.1430i | -0.3162-0.3162i |
| s_{14} | -0.3968-0.4259i | -0.4093-0.4393i | -0.4133-0.4436i | -0.4146-0.4450i | -0.4150-0.4455i | -0.4151-0.4455i | -0.3162-0.9487i |
| s_{15} | -1.0844-0.5358i | -1.0821-0.5258i | -1.0818-0.5213i | -1.0817-0.5197i | -1.0817-0.5191i | -1.0817-0.5191i | -0.9487-0.3162i |
| s_{16} | -0.4578-1.1195i | -0.4480-1.1166i | -0.4435-1.1159i | -0.4419-1.1158i | -0.4414-1.1157i | -0.4414-1.1157i | -0.9487-0.9487i |

TABLE V: Optimized irregular source constellations obtained from $\mathbf{P1}$ for EVM = -20 dB.

| | $\bar{\gamma} = 10$ dB | $\bar{\gamma} = 15$ dB | $\bar{\gamma} = 20$ dB | $\bar{\gamma} = 25$ dB | $\bar{\gamma} = 30$ dB | $\bar{\gamma} = 35$ dB | $\bar{\gamma} = 40$ dB |
|----------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|
| s_1 | 0.2558+0.2570i | 0.1256+0.3821i | 0.3183+0.5394i | 0.3416+0.5449i | 0.1783+0.5508i | 0.2449+0.5823i | 0.2698+0.5731i |
| s_2 | 0.2964+0.8466i | 0.3042+1.0675i | 0.2667+1.2918i | 0.4887+1.2152i | 0.5556+1.1125i | 0.5516+1.1688i | 0.5504+1.1723i |
| s_3 | 0.8474+0.2951i | 0.7452+0.3088i | 0.7206+0.0613i | 0.5920+0.0227i | 0.5448+0.0690i | 0.6129+0.0808i | 0.6027+0.0503i |
| s_4 | 1.0600+1.0603i | 1.0811+0.8687i | 1.0166+0.7268i | 1.0885+0.5347i | 1.0502+0.5181i | 1.0917+0.5430i | 1.0781+0.5286i |
| s_5 | 0.2569-0.2528i | 0.3737-0.1214i | 0.1044-0.0005i | -0.0392+0.0707i | -0.0367-0.0387i | 0.0073-0.0017i | -0.0000+0.0001i |
| s_6 | 0.2970-0.8470i | 0.3149-0.6880i | 0.4066-0.5030i | 0.3360-0.5218i | 0.3791-0.5304i | 0.3928-0.4993i | 0.3618-0.5208i |
| s_7 | 0.8503-0.2928i | 1.1387-0.2856i | 1.2131-0.4198i | 1.1608-0.3077i | 1.1396-0.2676i | 1.1473-0.3459i | 1.1533-0.3389i |
| s_8 | 1.0565-1.0680i | 0.7874-1.1087i | 0.6804-1.1107i | 0.8012-0.9992i | 0.8335-1.0045i | 0.7054-1.0807i | 0.7409-1.0639i |
| s_9 | -0.2538+0.2560i | -0.3638+0.1469i | -0.4201+0.2552i | -0.5525+0.3285i | -0.4397+0.4333i | -0.3655+0.4764i | -0.3449+0.4970i |
| s_{10} | -0.2913+0.8492i | -0.3085+0.8016i | -0.2225+0.8081i | -0.1857+0.8910i | -0.2224+1.1413i | -0.2863+1.1568i | -0.2821+1.1683i |
| s_{11} | -0.8489+0.2947i | -1.0458+0.2746i | -1.2548+0.2170i | -1.3013+0.1724i | -1.2391+0.0654i | -1.2842-0.0908i | -1.2916-0.1103i |
| s_{12} | -1.0642+1.0611i | -0.9433+1.0372i | -0.8674+0.9085i | -0.8979+0.9389i | -0.9584+0.8446i | -1.0032+0.6814i | -0.9966+0.6701i |
| s_{13} | -0.2542-0.2541i | -0.1586-0.3745i | -0.2246-0.4976i | -0.2515-0.4941i | -0.2372-0.6334i | -0.2209-0.5648i | -0.2579-0.5467i |
| s_{14} | -0.2953-0.8508i | -0.2363-1.1303i | -0.0916-1.1662i | 0.0011-1.1594i | 0.0080-1.2721i | -0.1084-1.2143i | -0.0820-1.1981i |
| s_{15} | -0.8496-0.2912i | -0.7501-0.3046i | -0.7587-0.2230i | -0.8020-0.2613i | -0.6306-0.1610i | -0.6226-0.0831i | -0.6322-0.0523i |
| s_{16} | -1.0631-1.0633i | -1.0644-0.8742i | -0.8870-0.8873i | -0.7798-0.9756i | -0.9248-0.8273i | -0.8630-0.8088i | -0.8697-0.8289i |

TABLE VI: The symbol point coordinates of optimized irregular relay constellations obtained from $\mathbf{P1}$ for EVM = -20 dB.

| | $\bar{\gamma} = 10$ dB | $\bar{\gamma} = 15$ dB | $\bar{\gamma} = 20$ dB | $\bar{\gamma} = 25$ dB | $\bar{\gamma} = 30$ dB | $\bar{\gamma} = 35$ dB | $\bar{\gamma} = 40$ dB |
|----------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|
| s_1 | 0.3362+0.1991i | 0.5258+0.1621i | 0.5197+0.2613i | 0.5371+0.2981i | 0.5451+0.2745i | 0.5423+0.2707i | 0.5513+0.2677i |
| s_2 | 0.2845+0.6588i | 0.1430+0.7752i | 0.2845+0.9786i | 0.3008+0.9950i | 0.3146+0.9903i | 0.3263+1.0320i | 0.3257+1.0337i |
| s_3 | 1.1261+0.2465i | 1.2013+0.1207i | 1.1824+0.0494i | 1.1923+0.0512i | 1.1897+0.0341i | 1.1811+0.0148i | 1.1768+0.0131i |
| s_4 | 1.0032+1.0929i | 0.8222+0.9263i | 0.9747+0.8024i | 0.9908+0.7926i | 0.9916+0.7751i | 1.0005+0.7699i | 0.9961+0.7645i |
| s_5 | 0.1466-0.2755i | 0.0613-0.2239i | 0.0434-0.3011i | 0.0289-0.2814i | 0.0150-0.2337i | 0.0036-0.1877i | -0.0014-0.1819i |
| s_6 | 0.2641-1.0003i | 0.2854-1.2970i | 0.3940-1.0441i | 0.3843-0.9899i | 0.3769-0.9852i | 0.3798-0.9999i | 0.3844-1.0050i |
| s_7 | 0.5847-0.2922i | 0.5221-0.4536i | 0.6068-0.3503i | 0.6070-0.3243i | 0.5952-0.3419i | 0.5813-0.3603i | 0.5790-0.3655i |
| s_8 | 1.1056-0.9783i | 1.1078-0.7495i | 1.1150-0.7565i | 1.0951-0.7785i | 1.0954-0.7797i | 1.0932-0.7709i | 1.0913-0.7697i |
| s_9 | -0.1459+0.2818i | -0.0575+0.2341i | -0.0458+0.3346i | -0.0374+0.3694i | -0.0338+0.4181i | -0.0203+0.4573i | -0.0188+0.4661i |
| s_{10} | -0.2756+1.0210i | -0.2939+1.2943i | -0.3936+1.0336i | -0.3854+0.9984i | -0.3824+1.0457i | -0.3947+0.9982i | -0.3960+1.0099i |
| s_{11} | -0.5814+0.2830i | -0.5181+0.4565i | -0.6143+0.3379i | -0.6091+0.2956i | -0.5933+0.2759i | -0.5875+0.2611i | -0.5892+0.2621i |
| s_{12} | -1.0972+0.9792i | -1.1084+0.7453i | -1.1190+0.7499i | -1.0905+0.7629i | -1.0728+0.7348i | -1.0665+0.7280i | -1.0640+0.7227i |
| s_{13} | -0.3385-0.2023i | -0.5301-0.1542i | -0.5212-0.2670i | -0.5519-0.3252i | -0.5753-0.3418i | -0.5761-0.3553i | -0.5852-0.3613i |
| s_{14} | -0.2925-0.6747i | -0.1412-0.7750i | -0.2733-0.9550i | -0.2778-0.9562i | -0.2719-0.9406i | -0.2637-0.9288i | -0.2591-0.9256i |
| s_{15} | -1.1283-0.2342i | -1.2014-0.1323i | -1.1885-0.0586i | -1.2031-0.0767i | -1.2036-0.0741i | -1.2051-0.0581i | -1.2008-0.0603i |
| s_{16} | -0.9917-1.1049i | -0.8182-0.9292i | -0.9648-0.8152i | -0.9814-0.8308i | -0.9903-0.8514i | -0.9943-0.8710i | -0.9901-0.8705i |

TABLE VII: The symbol point coordinates of optimized irregular source constellations obtained from $\mathbf{P2}$ for EVM = -20 dB.

| | $\bar{\gamma} = 10$ dB | $\bar{\gamma} = 15$ dB | $\bar{\gamma} = 20$ dB | $\bar{\gamma} = 25$ dB | $\bar{\gamma} = 30$ dB | $\bar{\gamma} = 35$ dB | $\bar{\gamma} = 40$ dB |
|----------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|
| s_1 | 0.2360+0.2346i | 0.3822+0.1611i | 0.2215+0.0485i | 0.0587-0.0425i | 0.0161-0.0377i | 0.0194-0.0154i | 0.0217-0.0123i |
| s_2 | 0.2876+0.8467i | 0.3102+0.7100i | 0.3839+0.5798i | 0.3846+0.4546i | 0.3673+0.5244i | 0.3589+0.5041i | 0.3590+0.5089i |
| s_3 | 0.8499+0.2877i | 1.0681+0.3063i | 1.1612+0.4040i | 1.2000+0.3927i | 1.2134+0.2249i | 1.2300+0.2441i | 1.2341+0.2312i |
| s_4 | 1.0660+1.0675i | 0.8958+1.0806i | 0.7581+1.1271i | 0.7555+1.0363i | 0.8601+0.9857i | 0.8359+0.9622i | 0.8396+0.9575i |
| s_5 | 0.2348-0.2340i | 0.1705-0.3977i | 0.2685-0.5276i | 0.3529-0.5720i | 0.3216-0.5862i | 0.3208-0.5610i | 0.3133-0.5614i |
| s_6 | 0.2879-0.8500i | 0.3075-1.0659i | 0.1199-1.2278i | 0.1777-1.2090i | 0.2594-1.2310i | 0.2648-1.2110i | 0.2698-1.2133i |
| s_7 | 0.8463-0.2853i | 0.7234-0.3064i | 0.7842-0.1359i | 0.7359-0.0872i | 0.6220-0.0417i | 0.6503-0.0482i | 0.6419-0.0444i |
| s_8 | 1.0692-1.0692i | 1.0761-0.9023i | 0.9461-0.8194i | 1.0407-0.7696i | 1.0339-0.6318i | 1.0215-0.6708i | 1.0202-0.6616i |
| s_9 | -0.2332+0.2351i | -0.1813+0.3931i | -0.2492+0.5123i | -0.2562+0.4946i | -0.2448+0.5381i | -0.2721+0.5368i | -0.2739+0.5337i |
| s_{10} | -0.2854+0.8479i | -0.2945+1.0688i | -0.0807+1.2023i | -0.0005+1.1110i | 0.0070+1.1846i | 0.0477+1.1643i | 0.0388+1.1681i |
| s_{11} | -0.8495+0.2875i | -0.7491+0.3102i | -0.8327+0.1923i | -1.1761+0.3335i | -1.1538+0.2931i | -1.1958+0.3091i | -1.1877+0.3110i |
| s_{12} | -1.0706+1.0698i | -1.0618+0.9220i | -0.9116+0.8732i | -0.7351+0.9855i | -0.7640+0.9683i | -0.7627+0.9793i | -0.7619+0.9852i |
| s_{13} | -0.2330-0.2329i | -0.3759-0.1643i | -0.3086-0.0805i | -0.5821+0.0043i | -0.5790+0.0207i | -0.6003+0.0116i | -0.5958+0.0136i |
| s_{14} | -0.2870-0.8487i | -0.3130-0.7361i | -0.3405-0.6293i | -0.2794-0.5419i | -0.3210-0.5658i | -0.3034-0.5478i | -0.3091-0.5447i |
| s_{15} | -0.8485-0.2859i | -1.0314-0.3137i | -1.1389-0.3980i | -1.0739-0.4871i | -1.0444-0.4906i | -1.0567-0.5078i | -1.0552-0.5098i |
| s_{16} | -1.0703-1.0707i | -0.9267-1.0655i | -0.7813-1.1209i | -0.6027-1.1031i | -0.5938-1.1549i | -0.5585-1.1495i | -0.5549-1.1618i |

TABLE VIII: The symbol point coordinates of optimized irregular relay constellations obtained from $\mathbf{P2}$ for EVM = -20 dB.

| | $\bar{\gamma} = 10$ dB | $\bar{\gamma} = 15$ dB | $\bar{\gamma} = 20$ dB | $\bar{\gamma} = 25$ dB | $\bar{\gamma} = 30$ dB | $\bar{\gamma} = 35$ dB | $\bar{\gamma} = 40$ dB |
|----------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|
| s_1 | 0.1357+0.2816i | 0.0529+0.2154i | 0.0403+0.3489i | 0.0363+0.3956i | 0.0191+0.5379i | -0.0189+0.5570i | -0.0389+0.5632i |
| s_2 | 0.2506+0.9837i | 0.3197+1.3067i | 0.4030+1.0273i | 0.3996+1.0009i | 0.4349+1.0746i | 0.4346+1.0569i | 0.4345+1.0468i |
| s_3 | 0.6841+0.3350i | 0.5325+0.4755i | 0.6115+0.3213i | 0.5914+0.2801i | 0.5345+0.2571i | 0.5600+0.3071i | 0.5475+0.2973i |
| s_4 | 1.1416+0.9377i | 1.0906+0.7754i | 1.1217+0.7442i | 1.0894+0.7328i | 1.0540+0.6592i | 1.1061+0.6879i | 1.0948+0.6634i |
| s_5 | 0.2805-0.1286i | 0.5241-0.1892i | 0.5272-0.2788i | 0.5523-0.3446i | 0.5621-0.3843i | 0.5928-0.3333i | 0.6081-0.3368i |
| s_6 | 0.3466-0.7405i | 0.1220-0.7403i | 0.2604-0.9563i | 0.2574-0.9588i | 0.1931-0.8868i | 0.1249-0.7849i | 0.1363-0.7607i |
| s_7 | 1.0308-0.2097i | 1.2452-0.1685i | 1.1968-0.0712i | 1.2007-0.0845i | 1.1798-0.1054i | 1.2023-0.1115i | 1.2162-0.1005i |
| s_8 | 0.9685-1.1525i | 0.7719-0.8821i | 0.9471-0.8245i | 0.9845-0.8563i | 0.9541-0.9208i | 0.8332-0.9603i | 0.8058-0.9972i |
| s_9 | -0.3278+0.1702i | -0.5150+0.1808i | -0.5157+0.2724i | -0.5397+0.2935i | -0.5137+0.2547i | -0.5222+0.1966i | -0.5320+0.1868i |
| s_{10} | -0.3439+0.7100i | -0.1182+0.7550i | -0.2733+0.9819i | -0.2874+1.0158i | -0.3332+1.1293i | -0.3343+1.1310i | -0.3294+1.1744i |
| s_{11} | -1.0341+0.2192i | -1.2301+0.1470i | -1.1893+0.0623i | -1.1890+0.0514i | -1.1391-0.0072i | -1.1412-0.0053i | -1.1686-0.0027i |
| s_{12} | -0.9612+1.1357i | -0.7809+0.8879i | -0.9543+0.8142i | -0.9877+0.8001i | -0.9774+0.7456i | -0.9458+0.7230i | -0.9184+0.7250i |
| s_{13} | -0.0735-0.2868i | -0.0536-0.2194i | -0.0449-0.3128i | -0.0169-0.2514i | 0.0237-0.1235i | 0.0409-0.0889i | 0.0372-0.0855i |
| s_{14} | -0.2567-0.9554i | -0.3257-1.3116i | -0.4005-1.0401i | -0.3985-0.9900i | -0.4372-1.1055i | -0.4176-1.2100i | -0.3728-1.1680i |
| s_{15} | -0.7043-0.3470i | -0.5262-0.4505i | -0.6093-0.3388i | -0.5915-0.3279i | -0.4846-0.3977i | -0.4567-0.4525i | -0.4663-0.4472i |
| s_{16} | -1.1370-0.9524i | -1.1093-0.7822i | -1.1207-0.7499i | -1.1008-0.7568i | -1.0704-0.7272i | -1.0580-0.7127i | -1.0541-0.7584i |