Cross interference compensation method of LARK-1 CO sensor responding to CO2

When using LARK-1 CO sensor to measure a mixture of CO and CO2, there will be cross interference brings by CO2. So, we should provide a compensation method to compensate this interference. This application note describes the compensation method step by step. This compensation method includes 3 steps: 1. Data aquisition; 2. Look-up table updating; 3. Concentration calculation. All the 3 steps should be completed in customers' instrument or equipment, NOT in LARK-1 CO sensor module. CO2 concentration should be provided by another CO2 senosr, eg. LARK-1 CO2 20%vol. Following table is a general table of reading of LARK-1 when input a mixture of CO and CO2, which is based on a lot of experiments by Promisense.

Table 1 Look-up table

CO(ppm) / CO2(ppm)	0	5000	10000	15000	20000	25000	30000	40000	50000	80000
0	0	5000	10000	15000	20000	25000	30000	40000	50000	80000
5000	58	5175	10192	15279	20305	25383	30375	40312	50350	80889
10000	89	5279	10331	15423	20531	25620	30630	40656	50717	81416
20000	127	5401	10525	15660	20856	25924	30948	41060	51243	81978
25000	147	5459	10617	15736	20994	26068	31089	41284	51419	82219
50000	211	5660	10936	16077	21475	26574	31576	41894	52340	83296
75000	270	5786	11161	16268	21757	26877	31793	42237	52565	84039
100000	311	5855	11244	16402	21943	27099	32126	42671	53051	84705
150000	395	6054	11555	16716	22467	27591	32685	43430	53911	86115
200000	459	6203	11835	17017	22895	28048	33131	44053	54635	87117

1. Data aquisation

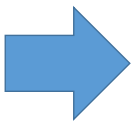
Input pure N2, 80000ppm CO (N2 ballenced), 200000ppm CO2 (N2 ballenced), and mixture of 80000ppm CO and 200000ppm CO2 (N2 ballencid) for 5 minutes respectively. Record ppm reading of LARK-1 CO sensor, which are C1, C2, C3, C4.

2. Look-up table updating

2.1 Uptade the FIRST and LAST column in table 1 to get following table 2.

Table 2 Updating of 4 vertices

CO(ppm) / CO2(ppm)	0	80000
0	0	80000
5000	58	80889
10000	89	81416
20000	127	81978
25000	147	82219
50000	211	83296
75000	270	84039
100000	311	84705
150000	395	86115
200000	459	87117



0	80000
C1-(C1-0)	C2-(C2-8000)
C3-(C1-0)	C4-(C2-80000)

As table 2, make correction of the 4 data in 4 vertices in table 1, the we get 4 concentration

data in right part of table 2. Then calculate $A = \frac{C3-(C1-0)}{459}$, $B = \frac{C4-(C2-80000)}{87117}$. Then update data in the FIRST column and LAST column with coefficinets A and B.

Table 3 Updating of 1st column and last column

CO(ppm) / CO2(ppm)	0	80000
0	0*1	80000*1
5000	58*((A-1)/200000*5000+1)	80889*((B-1)/200000*5000+1)
10000	89*((A-1)/200000*10000+1)	81416*((B-1)/200000*10000+1)
20000	127*((A-1)/200000*20000+1)	81978*((B-1)/200000*20000+1)
25000	147*((A-1)/200000*25000+1)	82219*((B-1)/200000*25000+1)
50000	211*((A-1)/200000*50000+1)	83296*((B-1)/200000*50000+1)
75000	270*((A-1)/200000*75000+1)	84039*((B-1)/200000*75000+1)
100000	311*((A-1)/200000*100000+1)	84705*((B-1)/200000*100000+1)
150000	395*((A-1)/200000*150000+1)	86115*((B-1)/200000*150000+1)
200000	459*A	87117*B

2.2 Calculate the data in other column

In experiments we find that when CO2 concentration does not changes, the reading of LARK-1 CO has linear relationship with CO concentration. So, we can update other data in table 1. For convenience of description, we use **x + subscripts** to represent a column of data with CO concentration of 0, ie. x0= (0*1), x1=58*((A-1)/200000*5000+1), x2= 89*((A-1)/200000*10000+1), ..., x9=459*A. We use **y** to represent the column of data with CO concentration of 80000ppm, ie. y0=(80000*1), y1=80889*((B-1)/200000*5000+1), y2=81416*((B-1)/200000*10000+1), ..., y8=86115*((B-1)/200000*150000+1), y9=87117*B. As shown in table 4. Then calculate CO concentration according to linear ratio, as shown in table 5.

Table 4

CO(ppm) / CO2(ppm)	0	80000
0	x0	y0
5000	x1	y1
10000	x2	y2
20000	x3	y3
25000	x4	y4
50000	x5	y5
75000	x6	y6
100000	x7	y7
150000	x8	y8
200000	x9	y9

Table 5

CO(ppm) / CO2(ppm)	0	5000	10000	15000	20000	25000	30000	40000	50000	80000
0	x0	(y0-x0)/80000 *5000+x0	(y0-x0)/80000 *10000+x0	(y0-x0)/80000 *15000+x0	(y0-x0)/80000 *20000+x0	(y0-x0)/80000 *25000+x0	(y0-x0)/80000 *30000+x0	(y0-x0)/80000 *40000+x0	(y0-x0)/80000 *50000+x0	y0
5000	x1	(y1-x1)/80000 *5000+x1	(y1-x1)/80000 *10000+x1	(y1-x1)/80000 *15000+x1	(y1-x1)/80000 *20000+x1	(y1-x1)/80000 *25000+x1	(y1-x1)/80000 *30000+x1	(y1-x1)/80000 *40000+x1	(y1-x1)/80000 *50000+x1	y1
10000	x2	(y2-x2)/80000 *5000+x2	(y2-x2)/80000 *10000+x2	(y2-x2)/80000 *15000+x2	(y2-x2)/80000 *20000+x2	(y2-x2)/80000 *25000+x2	(y2-x2)/80000 *30000+x2	(y2-x2)/80000 *40000+x2	(y2-x2)/80000 *50000+x2	y2
20000	x3	(y3-x3)/80000 *5000+x3	(y3-x3)/80000 *10000+x3	(y3-x3)/80000 *15000+x3	(y3-x3)/80000 *20000+x3	(y3-x3)/80000 *25000+x3	(y3-x3)/80000 *30000+x3	(y3-x3)/80000 *40000+x3	(y3-x3)/80000 *50000+x3	y3
25000	x4	(y4-x4)/80000 *5000+x4	(y4-x4)/80000 *10000+x4	(y4-x4)/80000 *15000+x4	(y4-x4)/80000 *20000+x4	(y4-x4)/80000 *25000+x4	(y4-x4)/80000 *30000+x4	(y4-x4)/80000 *40000+x4	(y4-x4)/80000 *50000+x4	y4
50000	x5	(y5-x5)/80000 *5000+x5	(y5-x5)/80000 *10000+x5	(y5-x5)/80000 *15000+x5	(y5-x5)/80000 *20000+x5	(y5-x5)/80000 *25000+x5	(y5-x5)/80000 *30000+x5	(y5-x5)/80000 *40000+x5	(y5-x5)/80000 *50000+x5	y5
75000	x6	(y6-x6)/80000 *5000+x6	(y6-x6)/80000 *10000+x6	(y6-x6)/80000 *15000+x6	(y6-x6)/80000 *20000+x6	(y6-x6)/80000 *25000+x6	(y6-x6)/80000 *30000+x6	(y6-x6)/80000 *40000+x6	(y6-x6)/80000 *50000+x6	y6
100000	x7	(y7-x7)/80000 *5000+x7	(y7-x7)/80000 *10000+x7	(y7-x7)/80000 *15000+x7	(y7-x7)/80000 *20000+x7	(y7-x7)/80000 *25000+x7	(y7-x7)/80000 *30000+x7	(y7-x7)/80000 *40000+x7	(y7-x7)/80000 *50000+x7	y7
150000	x8	(y8-x8)/80000 *5000+x8	(y8-x8)/80000 *10000+x8	(y8-x8)/80000 *15000+x8	(y8-x8)/80000 *20000+x8	(y8-x8)/80000 *25000+x8	(y8-x8)/80000 *30000+x8	(y8-x8)/80000 *40000+x8	(y8-x8)/80000 *50000+x8	y8
200000	x9	(y9-x9)/80000 *5000+x9	(y9-x9)/80000 *10000+x9	(y9-x9)/80000 *15000+x9	(y9-x9)/80000 *20000+x9	(y9-x9)/80000 *25000+x9	(y9-x9)/80000 *30000+x9	(y9-x9)/80000 *40000+x9	(y9-x9)/80000 *50000+x9	y9

3. Cocentration calculation

3.1 For convenience of description, we replace the symbols and formulas in table 5 with **z + subscripts**, ie. (z00.....z90)=(x0.....x9), (z09.....z99)=(y0.....y9). From column 2 to column 9 is replaced with z01……z98 in table 6.

Table 6 Updated look-up table

CO(ppm) / CO2(ppm)	0	5000	10000	15000	20000	25000	30000	40000	50000	80000
0	z00	z01	z02	z03	z04	z05	z06	z07	z08	z09
5000	z10	z11	z12	z13	z14	z15	z16	z17	z18	z19
10000	z20	z21	z22	z23	z24	z25	z26	z27	z28	z29
20000	z30	z31	z32	z33	z34	z35	z36	z37	z38	z39
25000	z40	z41	z42	z43	z44	z45	z46	z47	z48	z49
50000	z50	z51	z52	z53	z54	z55	z56	z57	z58	z59
75000	z60	z61	z62	z63	z64	z65	z66	z67	z68	z69
100000	z70	z71	z72	z73	z74	z75	z76	z77	z78	z79
150000	z80	z81	z82	z83	z84	z85	z86	z87	z88	z89
200000	z90	z91	z92	z93	z94	z95	z96	z97	z98	z99

3.2 Calculate the data when CO2 concentration does not change but CO concentration changes. First, find out the interal of CO2 value, eg. CO2 = 83976ppm, which is between 75000ppm and 100000ppm. Then, calculate all the CO reading from 5000ppm to 8000ppm with scale factor, as shown in table 7.

Table 7

CO(ppm) / CO2(ppm)	0	5000	10000	15000	20000	25000	30000	40000	50000	80000
75000	z60	z61	z62	z63	z64	z65	z66	z67	z68	z69
m=83976	(z70-z60)/ (100000-75000)* (m-75000)+z60	(z71-z61)/ (100000-75000)* (m-75000)+z61	(z72-z62)/ (100000-75000) *(m-75000)+z62	(z73-z63)/ (100000-75000) *(m-75000)+z63	(z74-z64)/ (100000-75000) *(m-75000)+z64	(z75-z65)/ (100000-75000) *(m-75000)+z65	(z76-z66)/ (100000-75000) *(m-75000)+z66	(z77-z67)/ (100000-75000) *(m-75000)+z67	(z78-z68)/ (100000-75000) *(m-75000)+z68	(z79-z69)/ (100000-75000) *(m-75000)+z69
100000	z70	z71	z72	z73	z74	z75	z76	z77	z78	z79

3.3 According to table 7 and LARK-1 CO reaing, we can calculate real CO reading of instrument. Pay attention please, in different CO2 concentration interval, table 7 is different, which should be updated in instrument if CO2 concentration changes. For convinience of description, we replace the formulas in table 7 with **m + subscripts**, as shown in table 8. Find the interval of LARK-1 CO reading, then DO linear look-up table operation based on two adjacent values, as shown in table 8. For example, LARK-1 CO reading **m** is between m4 and

m5. The real reading of instrument should be Concentration(CO)=(25000-20000)/(m4-m5)*(m-m4) +20000.

Table 8

CO(ppm)	0	5000	10000	15000	20000	25000	30000	40000	50000	80000
LARK-1 reading	m0	m1	m2	m3	m4	m5	m6	m7	m8	m9