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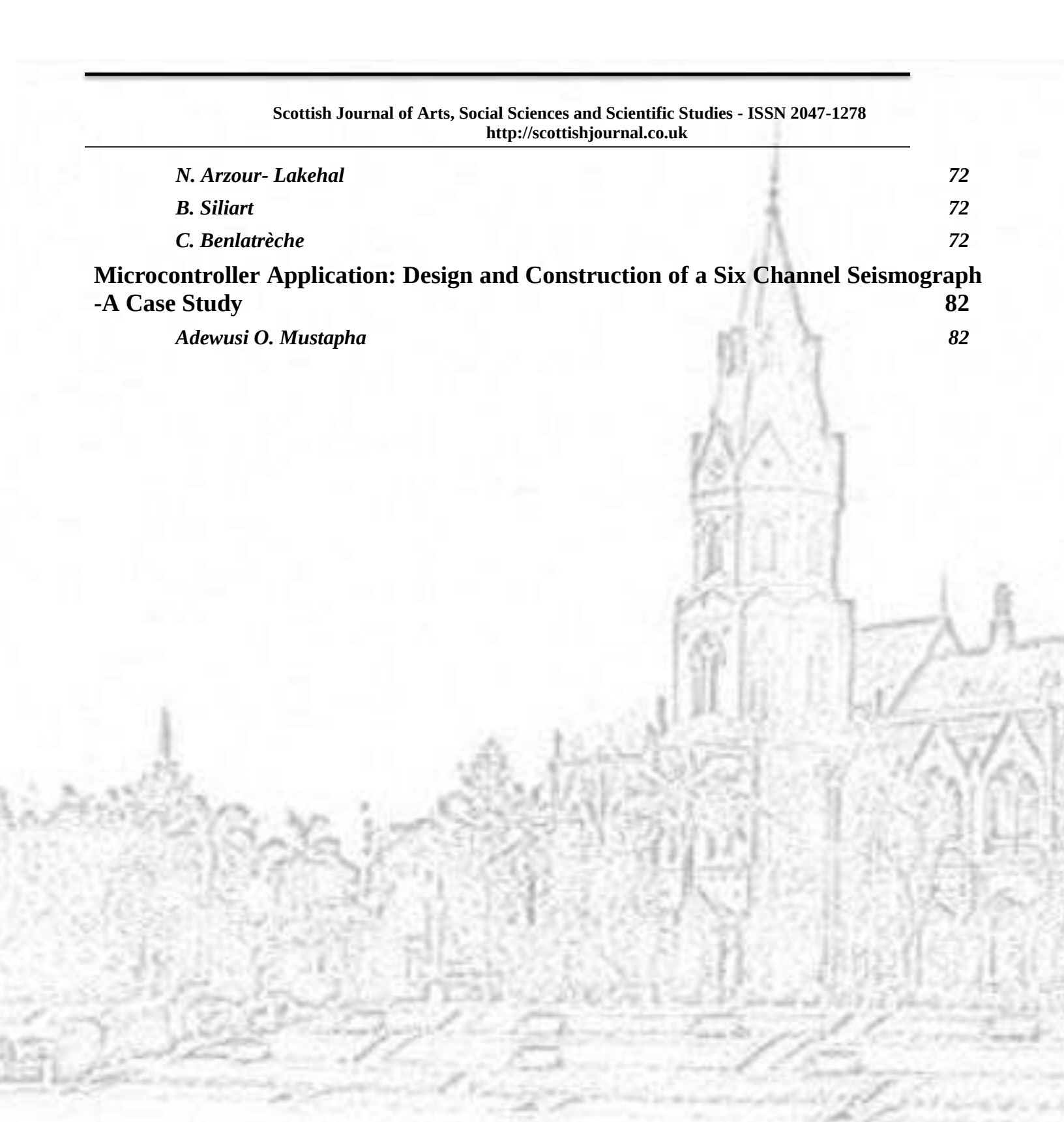

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Ìṣùaà Numerals System

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Abstract

This paper explores the mathematical conceptualization and arithmetical operations that are expressed by the linguistic forms of the numeral systems of 'Ìṣùà' an Ehuami (Ùhàmì) language, a member of the Akedoid language family of Niger Congo spoken in Akoko South- East, Ondo State, Nigeria. Direction of Ìṣùà counting is from left to right. The morphology of the numerals indicates Ìṣùà basic elements as 1, 2, 3, 4, 5, 10, 20 and three basic points of bundles as10, 20, and 200. The paper shows ability of the native speaker to start with the same basic elements but combine them in intricate and create ways and patterns to produce unique and effective numeral system as observed of African Languages.

1.0. Introduction

Úhàmì (known as Ehuami in the literature) speakers are bilingual. The speakers acquire Ùhàmì and Yoruba from childhood. The Yoruba numeral system is learnt alongside that of Ùhàmì. Linguists have observed that 'numeral system in most African Languages is either based on five, decimal (base ten) or vigesimal (base twenty)' Oyebade and Agoyi (20012), Oduyoye (1969: 3) comments, 'in counting on fingers and toes, the first point of rest is at the number 5, the number of fingers on one hand ……10 [ten] is another point of rest [i.e. the number of fingers on the two upper limbs]. ….20 (twenty) is complete in the system of counting on fingers and toes…..' Ùhàmì attests similar counting with some modifications. Each of the units the language attests is discussed one after the other with reference to the mathematical calculation involved in the system.

1.1 Úhàmì (Ehuami) Counting System: One-Ten

The count from one to ten as revealed from the data collected is presented in the table below:

Table I

Figure	Counting system	Ùhàmì	Gloss
1	1	ɔdá	one
2	2	èva	two
3	3	ésà	three
4	4	énì	four
5	5	íʃè	five
6	6	ɛ̀sɛsɛ∃	six
7	7	itʃenà	seven
8	8	iniénì	eight
9	9	isíénì	nine
10	10	igbe/ikwe	ten

Observe the data on table one attests Ùhàmì affixation. The affixes in this case are prefixes and suffixes. The initial vowel in each lexical item is presumed to be a prefix.

The implication is that the lexical items are assumed to be formed as:

1. ɔ-dá è- dà, é- sà, é- nì,
pref one pref two pref three pref four

í- ʃè, ɛ̀-sɛsà, i- ʧenà, í- niénì, i-sienì, ì- gbe
pref five pref six pref seven pre eight pre nine pre ten

The prefix has five allomorphs. They are:

2 [í-] í-ʃè, í- ʧenà, í-niénì,
[i] i- ʧenà, i-sienì
[ì] ì-gbè
[ɛ̀ -] ɛ̀-sɛsà
[è-] è-dà, è-ni

[é-] é-sà
[ɔ-] ɔ-da

From the lexical items for 2-4 we observe that the prefix vowel is /e/ (though é-sà attests tonal change). The prefix for 5, 6, 7, 8, 9 and 10 differs from the /e/, While 5, 7, 8, 9, and 10 make use of /i/, 6 features ɛ. The shape of the word for '6' and '8' indicates that the lexical items are formed by reduplication of the basic lexical items for '3' ésà and '4' ènì. Thus:

3. ésà + ésà→ ɛ́-sɛsà énì + énì→íniénì
three+ three→ double three '3+3 = 6' four + four→ double four '4 + 4 =8

The suffix in each item is presumed to be the last syllable of the word. They are:

3a) [sà] ɛ́- sɛ -sɛ∃ [nà] í- ʧe -nà, í- nié - nì
Pre- six suffix pre seven suffix pre eight suffix
[nì] i- sie -nì
Pre nine suffix

The root morphemes are: da 'one' va 'two', sà 'three', ni 'four' ʃè 'five', sɛ 'six' ʃe 'seven' nie 'eight' sie 'nine' and gbè 'ten'. Let us examine Ùhàmì counting system from eleven to twenty[1].

2. Ùhàmì counting system: Eleven to Twenty

The way Ùhàmì counts from eleven to twenty is presented on table 2 below.

Table II

Figure	Conputation	Linguistic Form[1i]		Gloss
11	10+1	ìgbèvèrɔdá	ten beautifies one	eleven
12	10+2	ìgbèvèrèvà	ten beautifies two	twelve
13	10+3	ìgbèvèrésà	ten beautifies three	thirteen
14	10+4	ìgbèvèrènì	ten beautifies four	fourteen
15	20+5	ìgbèvèrìʃè	ten beautifies five	fifteen
16	20+6	ìgbèvèrɛ́sɛsɛ∃	ten beautifies four	sixteen
17	20+7/-3+20	ìgbèvèriʃena/àvɛdɛsawudʒʲè	ten beautifies seven/less three from twenty	seventeen
18	20+8/2+20	ìgbèvèrìnieni/àvèdèvawudʒʲè	ten beautifies eight/ less two from twenty	eighteen
19	20+9/-1+20	ìgbèvèrisieni/àvɔdɔ́dáwudʒʲè	ten beautifies nine/less one	nineteen

[1] A speaker claims that the Ìṣùà word for six means three multiply by two or three in two places (that is three-three). The speakers claim confirms our observation that the lexical item for six and eight are formed by reduplication of the root morpheme for 3 'sa'and 4 'ni'.

			from twenty	
20	20	ùdʒè/ɔ≡gbɔ∃rɔ∃/ɛgbèrì-	twenty	twenty

Ìsùà counting system as on table 2 shows that from 11-16 attests addition of unit number to ten; 17-19 feature two forms of calculation: addition of 7, 8, and 9 to 10; removal of 3, 2 and 1 from twenty to form àvɛdɛsawudʒʲè, àvɛdevawudʒʲè respectively. Thus, the morphemes may be said to be:

4. (i) ìgbè- vère - ɔdá → ìgbèvèrɔdá[2] ìgbè vère ɔdá → ìgbèvèrɔdá

ten add one eleven ten add one eleven
ìgbè vère èvà → /ìgbèvèrèvà ìgbè vère èvà → ìgbèvèrèvà
ten add two twelve ten add two twelve
ìgbè-vèri-ésà →ìgbèvèrésà ìgbè-vèri-ésà →ìgbèvèrésà
ten add three thirteen ten add three thirteen
ìgbè-vère-ènì→ìgbèvèrènì ìgbè-vère-ènì→ìgbèvèrènì
ten add four fourteen ten add four fourteen
ìgbè-vèri-iʃè/→ìgbèvèriʃè ìgbè-vèri-iʃè/→ìgbèvèriʃè
ten add five fifteen ten add five fifteen
ìgbè-vère-ɛ́sɛsɛ∃→ìgbèvèrɛ́sɛsɛ ìgbè-vère-ɛ́sɛsɛ∃→ìgbèvèrɛ́sɛsɛ
ten add six sixteen. ten add six sixteen.
ìgbè-vèri-iʃena→ìgbèvèriʃena àvɛd- ésà- ùdʒʲè →àvɛdésùdʒʲè
ten add seven seventeen remove three from twenty seventeen
ìgbè-vère-ìnieni→ìgbèvèrìnieni àvɛd- èva- ùdʒʲè → àvɛdèvùdʒʲè
ten add eight eighteen remove two from twenty eighteen
ìgbè-vère-isieni→ìgbèvèresieni àvɛd- ɔdá- ùdʒʲè → àvɛdɔdùdʒʲè
ten add nine nineteen -remove one from twenty nineteen
ùdʒʲè ùdʒʲè
twenty twenty

Observation of the number from eleven to nineteen comfirms that numbers 1-9 do attest affixes identified in section one above. The morphemes are presumed to be: ɔ-dá 'one', é-và 'two', é-sà three and è-nì 'four' í-ʃè 'five, ɛ́-sɛ-sà 'six' i-ʃe-na 'seven' í-ni-é-ni 'eight' and i-si-e-ni 'nine'. The output of each form is a result of a morpho-phonological process of compounding in which some lexical items are combined to for a new world as in

5. igbe veri ɔ≡dá → igbeverɔ≡dá 'eleven'
ten add one 'eleven'

The morphological process that assumes addition from 1-9 in colon 4A is similar to English calculation which attests addition from left to right and addition of unit to

[2] The lexical item for addition -vèri- literarily means beautifies. In addition, data collected from younger generation attests -nɔb- in place of -vèri-.

bundle. The data in 4b is likely to be the form of the calculation. It attests a direction of calculation from right to left and removal of unit from bundle. The direction of calculation proto Ùhàmì attests is similar to the one found in some Niger-Congo language such as Àbèsàbèsì, Yorùbà and others. Note that this type of calculation is now endangered by the call for the unified westernized form of calculation system by linguists in Nigeria. The direction of calculation, addition, subtraction and multiplication phenomenon in Ùhàmì will be clearer with higher numbers.

Ùhàmì Counting System: Twenty-One to thirty

The numbering from twenty one to thirty attest similar addition and subtraction from the next bundle as already discussed.

Table III

figure	Computation	Ùhàmì		Gloss
21	20+1	údʒʲeverɔdá	twenty beautifies one	twenty one
22	2o+2	údʒéverèvà	twenty beautifies two	twenty two
23	20+3	údʒúvɛrésà	twenty beautifies three	twenty three
24	20+4	údʒévɛrénì	twenty beautifies four	twenty four
25	20+5	údʒévɛrìʃè	twenty beautifies five	twenty five
26	20+6	údʒévɛrɛsɛsà	twenty beautifies six	twenty six
27	20+7/-3+20	údʒé verénà/àvɛdɛsɔgbà	twenty beautifies seven	twenty seven
28	20+8/-2+20	údʒúverìniénì/àvɛdèvɔgbà	twenty beautifies eight	twenty eight
29	20+9/-1+20	údʒéverisíénì/àvɛdɔdáɔgbà	twenty beautifies nine	twenty nine
30	30	ɔgba	thirty	thirty

From twenty one to thirty Úhamì attests phrase formation; more than two morphemes as show in eleven to twenty above.

6.

A	B
údʒé -vere- ɔda	údʒé -vere- ɔda
twenty beautifies one	twenty beautifies one
údʒé -vere -èvà	údʒé -vere -èvà
twenty beautifies two	twenty beautifies two
údʒé - vere -ésà	údʒé - vere -ésà
twenty beautifies three	twenty beautifies three
údʒé -vere -énì	údʒé -vere -énì
twenty beautifies four	twenty beautifies four
údʒé -vere -ìʃè	údʒé -vere -ìʃè
twenty beautifies five	twenty beautifies five
údʒé -vere -ɛsɛsà	údʒé -vere -ɛsɛsà
twenty beautifies six	twenty beautifies six
údʒé -vere -isiena	/àvɛd- ésà- ɔgbà→ àvɛdɛsɔgbà
twenty beautifies seven	less three thirty twenty-seven
údʒé -vere -ìnienì	/àvɛd-èvà-ɔgbà→ àvɛdèvɔgbà

twenty beautifies eight less two thierty twenty-eight
údʒé -vere -isieni /àvɛd-ɔdá-ɔgbà→ àvɛdɔdáɔgbà
twenty beautifies nine less one thirty twenty-nine
ɔgbà
thirty

The data in 4 and 6 attest the deletion of first vowel. Again the mathematical calculation in 6A attests only addition of the smaller units to the bundle, 17-19 in 4B and 6B attests right to left direction of calculation as evident in the remover of units from bundle. The implication of this supposition is that Ùhàmì operates a base four system which is unique, The present study is not able to account for this phenomenon.

The morphological process of the lexical items in 4A above, attests addition of basic numbers 1-9 to twenty, 6B attests arithmetic process similar to the one observed in 4B. Note that in 10-20 only the lexical item for 1-9 are added. (see sections 1 and 2). The subtraction observed in units thirty five to thirty nine is similar to the one analyzed in (2). In addition, the lexical item for twenty is multiplied by two.

4. Computation from Thirty –Forty

The numeral system from thirty to forty is similar to the numbering from twenty to thirty; however the language attests the multiplication of twenty to form lexical item for forty. Table 4 presents data on such numeral

Table V

figure	Counting system	Ìṣùà		Gloss
31	30+1	ɔgbàverɔdá	thirty beautifies one	thirty one
32	2+(20x2)	ɔgbàverevá	thirty beautifies two	thirty two
33	3+(20x2)	ɔgbàverésà	Thirty beautifies three	thirty three
34	4+(20x2)	ɔgbàverénì	thirty beautifies four	thirty four
35	5+(20x2)	ɔgbàveríʃè	thirty beautifies five	thirty five
36	6+(20x2)	ɔgbàverɛsɛsɛ	thirty beautifies six	thirty six
37	7+(20x2)	ɔgbàverísièní/àvɛdʒésɛgbérevá	thirty beautifies seven	thirty seven
38	30+8	ɔgbàveríniéní/àvɛdʒèvɛgbérevá	thirty eight	thirty eight
39	30+9	ɔgbàverísénì/àvɛdʒɔdɛgbérevà	thirty beautifies nine	thirty nine
40	20+2	ɛgbérevá	twenty multiplied by two	forty

From table IV Úhàmì attests the infixation of '-vere-'; a younger speaker claims the infix is -nɔb-. I presume the speech of the younger speaker is more of innovation influenced by language contact; since the two morphemes mean 'beautifies', I assume -nɔb- (as in ɔgbànɔbɔdá 'thirty add one') is a variant of 'vere. Again the two forms of calculation is observed in 37-40. The mathematical calculation process from 37 to 39 features subtraction, and multiplication, 40 features only multiplication, the above phenomenon is represented in 7i) and 7ii)

7i) -ésà ɛgbére èva
-3+ (20x 2) = -3+40=37

-èva ɛgbére èva
-2+ (20x 2) = -2+40=38
-ɔdá ɛgbére èva
-1+ (20x 2) = -1+40=39

7ii) ɛgbére èva
20 x 2 =40

The mathematical calculation of Ùhàmì numerals from 40 to60 attests some interesting processes similar to the one Agoyi (2012) discussed in Àbèsàbèsì. The data is oin table VI below.

Table IV

Figure	Counting system	Linguistic Form		Gloss
41	(20x2)+1	ɛgbérevàverɔdá	twenty multiply by two beautifies one	forty-one
42	(20x2)+2	ɛgbérevàverevà	twenty multiply by two beautifies two	forth-two
43	(20x2)+3	ɛgbérevàverésà	twenty multiply by two beautifies three	forty-three
44	(20x2)+4	ɛgbérevàverénì	twenty multiply by two beautifies four	forty-four
45	(20x2)+5	ɛgbérevàveríʃè	twenty multiply by two beautifies five	Forty-five
46	(20x2)+6	ɛgbérevàverɛ́sɛsɛ̀	twenty multiply by two beautifies six	forty six
47	(20x2)+7	ɛgbérevàveritʃenà	twenty multiply by two beautifies seven	forty-seven
48	(20x2+8	ɛgbérevàveríniénì	twenty multiply by two beautifies eight	forty-eight
49	(20x2)+9	ɛgbérevàverisienì	twenty multiply by two beautifies nine	forty-nine
50	(20x2)+10	ɛgbérevàverigbe	twenty multiply by two beautifies ten	fifty
51	(20x2)+10+1	ɛgbérevàverigbeverɔdà	twenty multiply by two beautifies ten beautifies one	fifty-one
52	(20x2)+10+2	ɛgbérevàverigbeverevà	twenty multiply by two beautifies ten beautifies two	fifty-two
53	(20x2)+10+3	ɛgbérevàverigbeverévà	twenty multiply by two beautifies ten beautifies three	fifty-three
54	(20x2)+10+4	ɛgbérevàverigbeverénì	twenty multiply by two beautifies ten beautifies four	fifty-four
55	(20x2)+10+5	ɛgbérevàverigbeveríʃè	twenty multiply by two beautifies ten	fifty-five

			beautifies five	
56	(20x2)+10+6	ɛgbérevàverigbeverésɛsɛ̀	twenty multiply by two beautifies ten beautifies six	fifty-six
57	-3(20x3)	àvɛdésà-ɛgbérésà	less three from twenty multiply by three	fifty – seven
58	-2+(20x3)	àvɛdevà-ɛgbérésà	less two from twenty multiply by three	fifty-eight
59	-1+(20x3)	àvɛdɔdá-ɛgbérésà	less one from twenty multiply by three	fifty-nine

Data in table VI above feature addition of 1-10 to the multiple of 20; after adding 20 multiply by two to ten in forming 50 (ɛgbérevàverigbe); units 1-7 are added to form higher numbers 51-56. The outcome of the process is the morphological realization of ɛgbérevàverigbever- meaning twenty multiplied by two plus ten plus one (or two or three, or four, or five or six). From 57-59 the data attests removal of 3-1 from twenty multiplied by three. The process shows how the language speakers try to avoid unnecessary repetition which may make the calculation cumbersome and difficult for younger ones to understand. Note that the children acquire this mathematical process from childhood. Number of ridges made by the father or number of yam tubers/ combs of corn harvested is counted by the developing child for record purpose. From the foregoing it is clear that the Ùhàmì attests base four, decimal (base ten) and vigesimal (base twenty)'. Figures above the bundle attest the addition of the lexical item for unit (1-9) and 1-6 as the environment dictates (cf. data in tables I-VI). The calculation from twenty to the highest number in Ùhàmì is presumed to be:

Table V vigesimal '(base 20)' and Decimal '(base ten)' (a)

	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	300	400
ɛgbɔΔ	ɔgbɔrɔ	ɔgbà	ɛgbɔreà	ɛgbɔreàverigbé	ɛgbɔrésà	ɛgbɔrésàverìgbé	ɛgbèrénì	ɛgbɔrénìverigbé	ɛgbɔríʃè	ɛgbɔríʃèverigbé	ɛgbɔrésɛsɛ	ɛgbɔrésɛsɛ̀verigbé	ɛgbɔriʧenà	ɛgbɔriʧenàverigbé	ɛgbɔrinénì	ɛgbɔrinié nìverigbé	ɛgbɔrisíénì	ɛgbɔrisíénìverigbé	úkwénà	ukwenaverɛgbíʧè	úkwénèva

Data on table V shows that Ùhàmì counting system has 200 as a separate unit. The attested unit is úkwénà 'two hundred'. From 200 the data collected show the manipulation and addition of the few basic lexical items of numerals in an interesting way to express higher numerals. In the language, 200 is the highest figure. The multiple of the highest denomination by highest denomination results in úkwénúkwénà 200x200 (40,000). The implication is that the language is able to express (úkwénà) ^{n} two hundred multiplied by any number within the system (200 ^{n}).

7 Conclusion.

The paper proves that Úhùamì numeral is made up of prefix and compounding of root morphemes to derive lexical items for each the number. The lexical item for '20' has three variants ɔ́gbɔ̀rɔ̀ in isolation, ùʤ̬ʲè in isolation as well as computation of numerals 21-30 and ɛgbɔ̀rɔ̀ when higher figure which involve multiple of twenty are calculate. ígbé is another important point of reference in Úhúàmì calculation. It is always stand as a bundle to be added to multiple of twenty, unit numbers are also added to it in realizing figures that attests structure like (20x?)+10+1,2,3,4,5,6. 200 is úhúàmì's highest denomination. The paper has some mathematical implication- the lower denominations are to be added always appear to the right of the higher one while the lower denominations to be subtracted always appear to the left of the higher one. The above claim has not been made in any language as far as we know. Furthermore, Úhùamì attest three bundles as: ígBé 'ten', ùʤ̬ʲè /ɔ́gbɔ̀rɔ̀ 'twenty' and úkwénà '200 hundred and Units 1-6 are added to '10 ,20 or multiple of '20+10', 3-1 are subtracted from bundle of 20or multiples s well as 200 'úkwénà' and multiples of 200.

References

Agoyi, T O (2001) Category of Number in Ekiromi, in *Inquiry in African languages and Literature* 4:64-80

Agoyi T. O (to appear) Morphology of Àbèsàbèsì Numeral system: A Case Study of Èkiròmì

Armstrong, Robert G, (1962) Yoruba Numerals. London: Oxford University press (for the Nigerian Institute of Social and Economic Research).

Oyebade F. O and Agoyi T. O(to appear) The Linguistic Form and calculation System of Numerals In Yoruba and Èkiròmì: A Comparison.

Awobuluyi Ọladele (2001): 'The development of Modern Yoruba'. In Istvan Fodor & Claude Hagège (eds), *Language Reform VI: History and Future*. Hamburg:

Helmut Buske Verlag :25-42.

Awobuluyi Ọladele (2008:96-110): Ẹ̀kọ́ Ìṣẹ̀dá Ọ̀rọ̀ Yorùbá.: Montem Paperbacks: Akure, Nigeria

Bamgbose, Ayo, (1986) *Yoruba a Language in Transition*. *J F Odunjo Memorial*

Lecture Series 1. Ibadan: Molukom: Ibadan Nigeria

Jensen Hans Sign, Symbol, and Script: An Account of Man's Efforts to, 3rd rev

and enl (ed) (1968) Germany.

Oduyoye, Modupe. (1969): *Yoruba: Numeration system.* daystar Press: Ibadan Nigeria.

Olubode Sawe, Funmi O. (2007) 'Yoruba Numerals: A Review and a New View'

Unpublished Post Graduate Seminal paper, 6th March 2007, Department of

Linguistics and Languages, Adekunle Ajasin University, Akungba -Akoko. Ondo,

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A Study on Environmental Worldview of Undergraduate Business Students in Malaysia

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Abstract

Rapid development and modernization in the last few decades has caused significance environmental issues in Malaysia. The current study intends to explore the state of awareness on the environmental sustainability among the undergraduate business students in Malaysia. Revised New Ecological Paradigm (NEP) developed by Dunlap and Van Liere was utilized to measure the state of awareness towards environmental sustainability among the undergraduate business students. The instrument comprised of fifteen items pertaining to five areas which include reality of limits to growth, antianthropocentricism, the fragility of nature's balance, rejection of exemptionalism, and the possibility of ecocrisis. A total of 307 undergraduate business students took part in the study. The questionnaires were distributed through lecturers teaching business related courses. Data analysis was carried out to determine the general state of awareness on environmental sustainability among the students. The analysis indicated that in general the students showed positive environmental worldview. Specifically, majority of the students exhibited moderate to strong support to the five areas mentioned above. The results of the study would be very valuable for policy makers such as the government, universities, and business organizations in discovering the current state of awareness on environmental sustainability among future managers and leaders. The understanding on the present state of awareness on environmental sustainability among the students is an important platform for the policy makers to come up with effective environmental sustainability initiatives.

Keywords: environmental awareness, environmental sustainability, new ecological paradigm, sustainable development, undergraduate students

Introduction

Malaysia has undergone rapid modernization and economic growth in the last few decades where such developments have transformed the country from an economic backwater in 1950s to one of the prominent economic powers in Asia. However, the developments have caused significant deteriorations towards the environment. Realizing on the importance of sustainable development, the government has undertaken numerous steps to ensure sustainability of the environment. The success of such environmental sustainability initiatives depends on the awareness of the current students who are going to be the future managers, leaders and stakeholders.

Studies on environmental world view of students at colleges and universities in some other countries indicate positive awareness among the students towards environmental sustainability. Sia Su (2008) in his study on environmental worldview among college students in the Philippine found that gender and environmental attitudes affect students' environmental concern and most of the students' expressed strong environmentally supportive views and beliefs. In a study involving university student in United Kingdom, Kagawa (2007) discovered that a majority of student respondents think sustainability is "a good thing" as well as strongly associating the concepts of sustainable development and sustainability with their environmental as against economic and social aspects. In an earlier study in Australia, Ridener (1997) indicated that many students have awareness towards environmental issues but he cautioned that such awareness might not result in significant action towards those environmental issues. Petegem and An Blieck (2006) conducted a comparative study on environmental awareness between children in Belgium and Zimbabwe where they found that children in both countries display ecological worldviews eventhough differences occur at the human dominance dimension. Realizing that the sustainability of the environment rests upon the commitment of these students as future stakeholders, numerous studies on young people's environmental concerns and attitudes have also been accomplished (Wals, 1992; Bogner & Wilhelm, 1996; Barraza, 1999; Connell et al., 1999; Fien et al., 2002; Loughland et al., 2002).

Dunlap et al (2000) in their article explained the concept "environmental worldview" in details. According to them the concept of environmental worldview started with environmental concern where the focus was mainly on air and water pollution as well as resource conservation. They further explained that the concept stresses on the need for man to establish a balance with nature, the limitation of society's growth and man domination over other living things.

Methodology

Study population and sample

The respondents of the study comprise of undergraduate students in faculty of business administration of a private university in Selangor, Malaysia. 350 questionnaires were distributed to the respondents through lecturers teaching business courses. The respondents were given one week to complete the questionnaire. After the one week period, 307 questionnaires were completed and usable for further analysis.

Measurement analysis

The Revised New Ecological Paradigm developed by Dunlap, R., Van Liere, K., Mertig, A., & Jones, R. E. (2000) was used as the instrument to measure the degree to

which people view humans as a part of nature rather than separate from nature. The instrument was developed based on earlier version of Dunlap and Van Liere's (1978) New Ecological Paradigm (NEP). The instrument is one of the most widely used methods to measure orientation, attitudes and behavior towards the environment. The respondents in the study were prompted with, *"Now we would like to get your opinion on a wide range of environmental issues. For each of the following statements please indicate the extent to which you agree or disagree*." This scale contains 15 items which are rated on a 7-point Likert scale, ranging from 1 (strongly disagree), 2 (disagree), 3 (slightly disagree), 4 (indifference), 5 (slightly agree), 6 (agree) to 7 (strongly agree). Items 2, 4, 6, 8, 10, 12, and 14 were reverse scored. Responses were summed in order to create a total scale score of the NEP. Scores range from 15 to 105, with high scores indicating complete acceptance of the NEP. Several socio-demographic variables such as gender, age, ethnicity and academic program were included in the survey instrument.

Results and Findings

General characteristics of respondents

The findings on the general background of the study are summarized in the following table.

Table 1: General characteristics of respondents

Demographic Factor	Frequency	Percentage
Gender		
Male	115	37.5
Female	192	62.5
Ethnicity		
Malay	134	43.6
Chinese	19	6.2
Indian	130	42.3
Others	24	7.8
Academic Program		
Bachelor of Business Administration (BBA)	183	59.6
Bachelor of Management (B. Mgmt)	108	35.2
Bachelor of Accounting (BACC)	16	5.2

The female respondents outnumbered their male counterparts where there were 192 (62.5%) female respondents compared to 115 (37.5%) male respondents. In term of ethnicity, 134 (43.6%) respondents were Malays, 19 (6.2%) were Chinese, 130 (42.3%) were Indian, and the other 24 (7.8%) were from other ethnic groups who mainly comprise of foreign students at the university. In term of academic program, 183 (59.6%) respondents were from BBA program, 108 (35.2%) were from B. Mgmt program and 16 (5.2%) were from BACC.

Table 2: Average Scores for Age and Summed NEP

	Minimum	Maximum	Mean	Std. Deviation
Age	18	34	22.0423	2.00037
Summed NEP	22	99	78.2573	10.9956

As shown in Table 2 above, the average age for the respondents is 22 years old in which the youngest is 18 years old and the oldest is 34 years old. In term of environmental world view, the average score is 78.2573 in which the lowest and highest scores among the respondents are 22 and 99 respectively. The average score of 78.2573 indicates that the respondents have relatively high positive attitudes towards the environment.

Socio demographic variables

Several statistical tests were utilized to examine the relationships between socio demographic variables and environmental worldview of the students. The tests mainly comprised of T-test, One-way ANOVA, and Pearson correlation.

Age and environmental worldview

Pearson correlation was used to test this relationship. The result of the test is summarized in table 3 below:

Table 3: Pearson Correlation between age and environmental worldview (N=307)

Variables	R	p value
Age and NEP scores	-0.003	0.962

The relationship between age and environmental worldview (as measured by the NEP) was investigated using Pearson correlation coefficient. As shown in the above table, there was no significant relationship between age and environmental worldview (p=0962). The R value of -0.003 indicate that there is almost no association between the two variables. The fact that most of the respondents come from similar age bracket is believed to contribute to this finding. As shown in Table 2, the standard deviation value for age is about 2 years.

Ethnicity and environmental worldview

A one-way between-groups analysis of variance was conducted to explore the association between ethnicity and environmental worldview of the students. The result is summarized in the following table 4:

Table 4: Analysis of variance between ethnicity and environmental worldview (N=307)

Variables	F	p value
Ethnicity and NEP scores	5.315	0.001

The subjects were divided into four groups according to their ethnicity (Malay, Chinese, Indian and others). As shown in the above table, there was a statistically significant difference at $p < 0.05$ level in NEP scores for the four ethnic groups: $F (3, 303) = 5.315$, $p = 0.001$. Despite reaching statistical significance, the actual difference in mean NEP scores between the four ethnic groups was not that large. This is confirmed by post-hoc analysis using Scheffe test. Post-hoc comparison using the Scheffe test indicated that the mean score for Chinese ($M = 68.9474$, $SD = 7.4198$) was significantly different from Malay ($M = 78.3284$, $SD = 7.7428$), Indian ($M = 79.500$, $SD = 13.5419$) and others ($M = 78.500$, $SD = 10.4798$). There were no significant differences in mean NEP scores among Malay, Indian and others.

Academic program and environmental worldview

A one-way between-groups analysis of variance was conducted to explore the association between academic programs and environmental worldview of the students. The result is summarized in the following table 5:

Table 5: Analysis of variance between academic program and environmental worldview (N=307)

Variables	F	p value
Academic program and NEP scores	6.656	0.001

The subjects were divided into three groups according to their academic programs (BBA, BACC and BOM). As shown in the above table, there was a statistically significant difference at $p < 0.05$ level in NEP scores for the three groups: $F(2, 306) = 6.656$, $p = 0.001$. Despite reaching statistical significance, the actual difference in mean NEP scores between the three groups was relatively small. This is confirmed by post-hoc analysis using Scheffe test. Post-hoc comparison using the Scheffe test indicated that the mean score for BOM (M = 81.00, SD = 13.0413) was significantly different from BBA (M = 77.1311, SD = 9.5275) and BACC (M = 72.6250, SD = 9.9558). There were no significant differences in mean NEP scores for BBA and BACC.

Gender and environmental worldview

Independent sample T-Test was utilized to examine the relationship between gender and environmental worldview of the students. An independent-sample t-test was conducted to compare the environmental worldview scores (NEP scores) for male and female respondents. The result is summarized in the following table 31:

Table 6: Independent sample t test for equality of mean P scores and gender (N=307)

Variables	t	p value
Gender and NEP scores	-1.457	0.146

The mean NEP score for female is slightly higher at 78.9635 compared to male at 77.0783. However, the mean for this study's dependent variable (NEP scores) did not indicate statistical significance, t = -1.457 and p value = 0.146. The magnitude of the differences in the mean scores between male and female respondents was very small.

Analysis of environmental worldview

Table 7: Frequency and mean distribution of NEP items[a]

NEP Items	**% distribution**							**N**	**Mean[b]**
	STD	**D**	**SLD**	**I**	**SLA**	**A**	**STA**		
1. We are approaching the limit of the number of people the earth can support	4.9	3.9	15.0	12.7	29.3	30.3	3.9	307	4.6
2. Humans have the right to modify the natural environment to suit their needs	13.7	20.5	11.7	11.7	9.8	14.0	18.6	307	4.0
3. When humans interfere with nature it often	3.9	2.0	2.0	3.9	9.1	33.2	45.9	307	6.0

	produces disastrous consequences								
4.	Human ingenuity will insure that we do NOT make the earth unlivable	6.8	32.6	21.2	19.5	8.8	7.2	3.9	307	4.7
5.	Humans are severely abusing the environment	3.9	0.0	2.0	13.7	20.8	35.2	24.4	307	5.5
6.	The earth has plenty of natural resources if we just learn how to develop them	40.1	41.4	11.4	3.9	0.0	2.3	1.0	307	6.1
7.	Plants and animals have as much right as humans to exist	2.9	2.0	2.9	6.2	8.8	32.2	45.0	307	5.9
8.	The balance of nature is strong enough to cope with the impacts of modern industrial nations	18.6	18. 9	11.4	12.7	12.7	17.9	7.8	307	4.3
9.	Despite our special abilities humans are still subject to the laws of nature	1.0	2.0	3.3	6.8	15.6	41.0	30. 3	307	5.8
10.	The so-called “ecological crisis” facing humankind has been greatly exaggerated	8.8	25.7	23.1	26.7	7.8	3.9	3.9	307	4.7
11.	The earth is like a spaceship with very limited room and resources	4.9	2.9	1.0	12.7	24.4	24.8	29.3	307	5.4
12.	Humans were meant to rule over the rest of nature	14.7	16.0	11.7	13.4	10.1	12.7	21.5	307	3.9
13.	The balance of nature is very delicate and easily upset	2.0	3.9	2.9	10.7	16.9	40.1	23.5	307	5.5
14.	Humans will eventually learn enough about how nature works to be able to control it	15.6	42.0	22.8	11.7	2.9	1.0	3.9	307	5.4
15.	If things continue on their present course, we will soon experience a major ecological catastrophe	2.0	0.0	1.0	3.9	5.9	18.6	68.7	307	6.4
Overall index		9.6	14.7	10.3	11.2	11.7	20.2	18.9	307	5.2

[a]STD=Strongly disagree, D=Disagree, SLD=Slightly disagree, I=Indifference, SLA=Slightly agree, A=Agree, STA=Strongly agree

[b]Mean scores after adjustment for reverse scoring for even numbered items. Higher score indicate pro-NEP worldview

The environmental worldview of the students was analyzed based on percentage distribution, means NEP scores and overall index as provided in table 7. After adjusting for reverse scoring items, the mean score for the 15 items was found to be 5.2 (out of possible 7). This indicates that the overall environmental worldview of students falls at the moderate positive level. As shown in table 7, about 53% of the respondents have mild to strong positive view on environment and about 36% have mild to strong negative view toward environment. The remaining 11% have indifference view towards the environment. The mean scores for eight positive worldview items range from 4.6 to 6.4, whereas, the mean scores for seven negative worldview items range from 3.9 to 6.1.

Rejection of Exemptionalism

According to Dunlap et. al (2000), this subscale consists of items 4, 9, and 14 and measures the respondents attitudes towards the rejection of exemptionalism. For item 4 (Human ingenuity will insure that we do NOT make the earth unlivable), 60.6% of the respondents specified that they have mild to strong disagreement with the statement, 19.9% of the respondents stated that they have mild to strong agreement with the statement and the remaining 19.5% of the respondents were indifference with regards to the statement. Almost two third of the students did believe that human ingenuity will insure that we do not make the earth unlivable. For item 9 (Despite our special abilities humans are still subject to the laws of nature), the students showed overwhelming agreement with the statement (86.9%). Only 6.3% of the students disagreed with statement and the remaining 6.8% of them were indifference on the statement. Majority of the students seem to believe that humans are still subject to the law of nature despite our special abilities. Findings on item 14 (Humans will eventually learn enough about how nature works to be able to control it) showed that the students have huge disagreement with the statement (80.4%), whereas, only 7.8% of them agreed with the statement and the other 11.7% of the students were indifference with regard to the statement. Majority of the students appear to have trust in human ingenuity and ability to overcome the constraints of nature. Generally, the students showed strong rejection towards exemptionalism.

Anti-anthropocentricism

This subscale consists of items 2, 7 and 12 and measures "the belief that nature exists primarily for human use and has no inherent value of its own (Dunlap et al., 2000). 45.9% of the students stated that they disagreed the statement in item 2 (Humans have the right to modify the natural environment to suit their needs), whereas, 42.4% of the students agreed with the statement and 11.7% of them were indifference. The students were almost equally divided in opinion on our right as human to modify the natural environment to suit our needs. For item 7 (Plants and animals have as much right as humans to exist), majority of the students (86%) agreed with the statement, whereas, 7.8% of them disagreed and the remaining 6.2% were indifference. Generally, the students seem to support the notion that plants and animals have as much right as humans to exist. The statement on humans were meant to rule over the rest of nature (item 12) is supported by 44.3% of the students. However, the other 42.4% of the students disagreed with the statement and the remaining 13.4% were indifference. Overall, nearly half of the students exhibit anti-anthropocentricism view towards the environment.

The Reality of Limits to Growth

This subscale consists of items 1, 6, and 11 and measures the attitudes of the respondents regarding the reality of the limits of growth in the environment (Dunlap et al., 2000). Almost two third (62.5%) of the students indicate agreement with the statement in item 1 (We are approaching the limit of the number of people the earth can support). However, 23.8% of the student disagreed with the statement and the other 12.7% were indifference. Almost all (93.3%) of the students disagreed with the statement that the earth has plenty of natural resources if we just learn how to develop them (item 6). Only 3.3% of the student agreed with the statement and the remaining 3.9% were indifference. When asked with the statement in item 11(The earth is like a spaceship with very limited room and resources), more than two third of the students (78.5%) showed agreement with it. Nevertheless, the other 8.8% disagreed with the statement and 12.7% were indifference. In general, majority of the students seem to accept the reality of the limits of growth in the environment.

The Fragility of Nature's Balance

According to Dunlap et al. (2000) this subscale consists of items 3, 8, and 13 and measures the attitudes of the respondents towards the fragility of nature's balance. Overwhelming number of students (88.9%) showed agreement with the statement in item 3 (When humans interfere with nature it often produces disastrous consequences), while 7.9% of them showed disagreement and 3.9% of the students were undecided. The students were also asked on their opinion towards the statement in item 8 (The balance of nature is strong enough to cope with the impacts of modern industrial nations). Almost half of the students (48.9%) disagreed with the statement but the other 38.4% agreed with it and the remaining 12.7% of the students were undecided. For item 13 (The balance of nature is very delicate and easily upset), majority of the students (80.5%) agreed with the statement while the other 8.8% of the students disagreed with it and the remaining 10.7% were unsure. Overall, majority of the students recognized the fragility of the nature's balance.

The Possibility of Eco-crisis

Dunlap et al. (2000) explained that the subscale consists of items 5, 10 and 15 and measures the attitudes of the respondents towards the possibility of an eco-crisis. Majority of the students (80.4%) seem to believe that humans are severely abusing the environment (item 5), whereas, 7.9% of them did not share the same believe and the other 13.7% of the students were undecided. For item 10 (The so-called "ecological crisis" facing humankind has been greatly exaggerated), slightly more than half (57.6%) of the students disagreed with it, whereas, 15.6% of the students agree with the statement and quite a significant number of students were indifference (26.7%). For item 15 (If things continue on their present course, we will soon experience a major ecological catastrophe), almost all of the students indicate agreement to the statement with only 3% indicate disagreement and 3.9% were undecided. On the whole, majority of the students accepted the view on the possibility of an eco-crisis.

Discussion and Conclusion

The study discovered that there are significant differences in environmental worldview among the students due to their ethnic background. Specifically, the Chinese showed significantly different worldview compared to other ethnic groups. Secondly,

students from BOM program showed significantly different environmental worldview compared to students from BBA and BACC. Thirdly, most of the students exhibited strong rejection towards exemptionalism. Fourthly, nearly half of the student exhibit anti-anthropocentricism view towards the environment. Fifthly, nearly all of the students seem to accept the reality of the limits of growth in the environment. Sixthly, majority of the students recognized the fragility of the nature's balance and accepted the view on the possibility of an eco-crisis.

Overall, the students exhibit positive environmental worldview. Exposure to courses and training on environmental sustainability would enable universities to churn out environmental conscious future managers and business leaders. It is obvious that the limitations of the current study include small sample size and sampling bias which impede the generalization of the results. However, it is believed that the study provides a glimpse on awareness of environmental sustainability among future business managers and leaders in the country.

References

Barraza, L. (1999). Children's drawings about the environment. *Environmental Education Research, 5*(1), 49–66.

Bogner, F. X. & Wilhelm, M. G. (1996). Environmental perspectives of pupils: the development of an attitude and behaviour scale. *The Environmentalist, 16*, 95–110.

Connell, S., Fien, J., Lee, J., Sykes, H. & Yencken, D. (1999). 'If it doesn't directly affect you, you don't think about it': a qualitative study of young people's environmental attitudes in two Australian cities. *Environmental Education Research, 5*(1), 95–113

Dunlap, R.E. and K.D. Van Liere. (1978). The New Environmental Paradigm: A proposes measuring instrument and preliminary results. *Journal of Environmental Education, 9*, 10-19.

Dunlap, R.E., K.D. Van Liere, A.G. Mertig and R.E. Jones. (2000). Measuring endorsement of the New Ecological Paradigm: A revisited NE P. *Journal of Social Issues, 56*, 425-442.

Fien, J., The-Cheong Poh Ai, I., Yencken, D., Sykes, H. & Treagust, D. (2002). Youth environmental attitudes in Australia and Brunei: implications for education. *The Environmentalist, 22*(3), 205–216.

Kagawa, Fumiyo. (2007). Dissonance in students' perceptions of sustainable development and sustainability: Implications for curriculum change. *International Journal of Sustainability in Higher Education, 8*(3), 317-338.

Loughland, T., Reid, A. & Petocz, P. (2002). Young people's conceptions of environment: a phenomenographic analysis. *Environmental Education Research, 8*(2), 187–197.

Petegem, Peter Van & An Blieck. (2006). The environmental worldview of children: a cross-cultural perspective. *Environmental Education Research, 12*(5), 625–635.

Ridener, L.R. (1997). University students' attitude to the environment: an Australian/USA comparison and the effects of an educational program. *Australian Journal of Environmental Education, 13*, 77-84.

Sia Su, Glenn L. (2008). Environmental worldview and concern of college students in the Philippines. *International Journal of Sustainability in Higher Education, 9*(1), 39-47.

Wals, A. E. J. (1992). Young adolescents' perception of environmental issues: implications for environmental education in urban settings. *Australian Journal of Environmental Education, 8,* 45–58.

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Identifying significant Land Use Patterns as major contributors to the Vibrancy of Urban Commercial Districts in the context of Malaysia

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Abstract

Commercial Districts are the most vibrant parts of the city. Malaysian cities are of no exception. Though they are mainly developed for the business and commercial purpose, it is dependent on many other activities that support them. Therefore, a commercial district becomes a mixed use zone. They are naturally vibrant, but there are issues that should be taken care of in order to sustain vibrancy. Vibrancy is operationally defined as the intensity of people present at the district in unit area in a given unit of time. Among many other independent variables that contribute to vibrancy, two major ones are security and legibility. These variables again have several components each. This study isolates one component from each variable namely mixed land use pattern and street element respectively, identify them as two independent variables, and tries to determine their contribution to the vibrancy of the district. In doing so, it also tries to identify which land use patterns are the most significant contributor in the context of Malaysia. This study selects Taman University, one of the busiest commercial districts in Johor Bahru, the strategic city of Malaysia. Statistical tool, namely principal component analysis is used to manifest a relationship between these three variables, followed by regression analysis. After analysis, it is found that several land use patterns indeed significantly contribute to the vibrancy of the district. It is also found that they have distinct time zone for their contribution. In order to sustain vibrancy along twenty four hours, this study suggests certain combinations of land use patterns and related street elements specific to the context of Malaysian urban commercial districts.

Keywords: Commercial District, Vibrancy, Security, Legibility, Land use pattern, Street element, Malaysia

Introduction

Malaysia is currently experiencing rapid urbanization. As a consequence of that, the urban built environment is growing fast. Every city develops its own pattern of growth. However, invariably several distinct districts are generated such as residential, commercial, industrial etc. Traditionally cities had one commercial center of activity, though modern cities often have smaller commercial districts as well. Though the major activity is business and commerce, many other activities need to be associated in order to support them. As a huge flow of people is involved in such commercial districts, it becomes a significant urban element. Not only commercial, but also infrastructural, environmental, social and cultural issues are involved. Many of them contribute to sustain this huge flow of people, which resembles its vibrancy. This study tries to find out several elements those contribute to sustain this vibrancy.

Background

Historically, commercial districts (CD) used to be located in the geographical center of the urban areas. Due to expansion of modern cities, more than one CD became common. However, the major CD gradually became known as central business district (CBD). CBDs were identifiable with densely placed tall buildings known as the architectural core (Crankshaw, 2009). The density became a consequence of concentration of as many business centers as possible within limited area defined by zoning laws. CBDs were also associated with high land value because of the huge demand. However, smaller CDs continued to exist in other parts of the city (CBD 2012). Nowadays, a big number of smaller CDs are common in many cities in the world. The cities of Malaysia are no exception.

While the local land use planning and zoning laws determine the physical boundaries, form and shape of the CDs, the physical characters are not the only concerns with CDs. Obviously CDs are places where economy is mobilized, which is the biggest asset of a CD. But the other concerns are not negligible either. It brings in high traffic, which creates air pollution, traffic jam. Due to excessive paving, urban heat island effect is often common in CDs. Besides, the concentration of big buildings may block sunlight and ventilation, excessive emission of greenhouse gas endangers air quality. All of them are concerns regarding environmental sustainability. Besides, CDs generate the biggest flow of people in the region. Their safety, security, and recreational demands remain as a social concern of CDs.

Vibrancy in Cds

There is always a vibrant atmosphere in CDs. Here, vibrancy responds to the number of people busy in different kind of activities at outdoors. From the urban designers' point of view, the challenge was always to design a space that can sustain this vibrancy. It is true that CDs can generate spontaneously. But in modern urban development, it is likely that urban designers and planners would be called upon to satisfy all those concerns in a structured and systematic method. Therefore, it is necessary to break down those concerns into measurable parameters. Yee and Manos (2012) summarized from different literature on vibrancy, and proposed a list of parameters. The physical parameters include legibility, mixed use, connectivity and accessibility. The environmental parameters include sustainability features regarding solar, wind, and other climatic and environmental elements. Social parameters include safety and security of

people, while the cultural parameters include sustaining local values, lexicons and cultural integrity as well as diversity.

Some of them are interrelated. For example, a vibrant CD at day time might become completely opposite after office hours. This can often bring in vandalism, crime, social violence inside the CDs at nighttime. Therefore, the issue of security becomes at stake. Mixed use, which is a physical parameter, that keeps the district active around the clock is therefore complementary to security, which is a social parameter. In another example, a good street network with effective transportation planning can prevent traffic problem, therefore can contribute to minimize air pollution, and hence enforce environmental sustainability.

Though these different parameters are likely to be taken care of by different set of professionals, for example, the economists for the economy generation, the environmental scientists for the environmental sustainability issues, the law and order forces on security issues and so on, often different professionals need to overlap their fields to build up better solutions to sustain the expected vibrancy. For example, urban designers are likely to concentrate on the physical parameters; however, they can contribute to social, cultural or environmental parameters as well.

Nevertheless, Liang and Sun (2006) insists that urban designers have three basic elements under physical parameter namely Land Use, Street Infrastructure, and Parcel, to play with for their contribution to build up and sustain a vibrant CD. Land Use can contribute to mixed use, diversity of people, as well as security issues. Street Infrastructure with traffic system incorporated with it can contribute to legibility of the CD, its accessibility or connectivity, as well as its environmental sustainability. Parcel or lot design can contribute to legibility as well as environmental sustainability. These studies can be complemented by researches from other related disciplines as mentioned earlier. This study concentrates on two of these elements namely Land Use and Street Infrastructure, and investigates how they can contribute to vibrancy through the issues of security and legibility respectively.

However, security and legibility are again functions of several independent variables. Security can be dependent on law and order situation as well as natural surveillance. A mixed land use pattern that generates activities all around the clock can significantly contribute to natural surveillance in the district. Therefore, the land use pattern is one of the variables that constitute security (ACC 2012), and is one of the focuses of this study.

Legibility is a function of different variables such as street furniture, nodes, landmarks, edges, gateways etc (Yee and Manos, 2012). This study focuses on street furniture, mainly located at shop front.

Considering the intensity of people in the outdoor space in CD as an indicator of vibrancy, the study therefore searches the relationship between vibrancy with security and legibility through studying the mixed land use pattern and street furniture at shop-front respectively.

The Three Variables

Intensity of People

Intensity of people in the street plays important role in creating vibrancy. Intensity is directly related with number of people present at a given time in a unit area of space. Though CDs have a dynamic image of people moving all around, however, people do not only walk. People in streets also perform considerable amount of static activities, such as sitting, standing, talking, eating and so forth (Gehl, 1986; Whyte, 1980; Hillier and Hanson, 1984). Throughout the day, more often than walking, people in streets sit or stand and talk, smoke, wait, distribute leaflets, sell, or simply 'watch other people' (Whyte 1980, p. 273). Therefore, the people who contribute to vibrancy are not always the people who are in dynamic motion, but also engaged in different activities. Gehl (1986) has categorized these activities into three types. These are 'necessary' activity such as walking that has to be done anyway, 'optional' activity such as standing or waiting etc. which responds to particular physical environment at a given moment, and 'social' activity such as sitting, eating or chatting etc. that involves social interaction (Owens, 1993).

Mixed Land Use Pattern

Land Use, as mentioned before, is one of the major urban design elements under the physical parameter. It affects the quality and quantity of pedestrian activities, and hence natural surveillance and hence security. Land use typically refers to the distribution of activities across space, including the location and density of different activities, where activities are grouped into relatively coarse categories, such as residential, commercial, office, industrial, and other activities (Handy et. al. 2002, p.65). All kinds of activities play important role for improving the quality of life. However, some of them play more significant role. However, in order to create vibrancy, mixed compatible type of land uses should be considered. Land use mix is defined as the relative proximity of different land uses within a given area. A mixed-use CD would include not shops of different kinds, but also homes, SOHOs, offices, parks, and perhaps other land uses. Furthermore, the vertical mixing of uses such as apartments or offices over stores can also add to the positive contribution towards visual variety, a broader range of pedestrian activities and a 24-hour presence to the street (Owens, 1993, p.131). Though guidelines for an effective land use mix are not standardized yet (Handy et al., 2002), however, according to Owens (1993), measuring the intensity of pedestrian activities can be considered as one of the indicators of an effective land-use. The business activities can be of different categories such as retailing, wholesale, office, restaurants, entertainment, store and so on. Different activities can play important roles as a meeting place and node of social activity in different context, and thus offer opportunities for more interaction among the different groups. Therefore, there is need to study which particular activity can play as the most significant catalyst to generate and sustain vibrancy at a particular context.

Street Elements

Recent research on urban configuration patterns indicates a strong relationship between properties of street layout and pedestrian movement (Hillier and Hanson, 1984). For example, presence of sidewalks along neighborhood streets with the purpose of traffic safety has association with intensity of people. Street facilities and furniture also have an impact on encouraging non-motorized travel and therefore the intensity of

people. For example, in some previous researches, properly located and treated benches appear to be the most effective street furniture as they attract more social activities to take place. Among many other, the recorded street furniture which affects pedestrian activities include benches, traffic lights, kiosks, auto pays, lighting amenities, bin, post box, flower box etc (Rakhshanifar, 2011). This study also searches for that street element which can contribute to vibrancy.

Study Context: Malaysian Cds

Turning to the context of urban Malaysia, the smaller CDs has been developed following local zoning law. The government usually permits a CD to grow in two methods. In an 'action area', it may allow a spontaneously generated existing commercial area to be re-developed as a CD, or it may invite developers to propose the planning of the CD along with the residential area in an empty site. For the latter, developers may propose both the location and the planning (TCPA 1976).

Number of shop lots

The number of the shop lots corresponds to a ratio of 1:10 with the number of residential units within the defined catchment area, though there are instances that the rate is lower than that (Chau, 2012). Moreover, there are also instances that there can be vacant shops, often blamed to the proximity of super or hyper markets near to the CD. Therefore, depending on the catchment area, the size of the CD may vary, and depending on the proximity of super or hyper markets, the active part of CD may vary.

Floor area ratio (FAR)

The current FAR is 4:1 whereas in older CDs, it was 2:1, which results in new ones having more stories.

Figure 1: a) Older CDs at Taman University, b) Newer CDs at (Taman Molek), Johor Bahru (Source: Authors)

Typology

The typology of CDs also varies. For example, in the outskirts of the cities, CDs can be totally separated from residential zones by primary or secondary arterial roads. In denser areas of cities, such CDs totally dedicated for commercial use may not be totally separated from residential zones; rather they can serve particular residential areas only separated by local streets. In such cases, a CD may also take the form of ribbon development parallel to the arterial roads either separated or not separated from it by service roads that are dedicated to the CDs only. Another particular typology of CD in

Malaysia cities is shopping streets where neighboring apartment buildings along a street give way their ground floors for shops (ibid).

Built form

The built form of the blocks relates back to the early Penang style of Malaysian architecture (1790 – 1850) with its distinctive row houses and arcaded sidewalk, which is within the property line. With the rise of modernism during the 1950s, the appearances changed, but however the concept of row-house still remains. The covered walkway in the front, popularly known as the 5-feet rule, still exists as a bylaw (TCPA 1976). The purpose remains the same, to protect pedestrians from rain and the tropical sun. The width of the frontage relates back to era of Southern Eclectic style (1850 – 1900), with one of the major reasons was to avoid high taxes (Mai-Lin 1998). It is said that taxes were determined by the width of the frontage, not the area of the shops. Therefore, back then the shop lots had narrow frontage with deep plan (Lim, 1993).

Street Network

There is a hierarchy of streets in CDs. Though not very distinctive as in residential districts, which have local streets, service streets, and backlanes with specified range of width, streets in CDs have their own distinctive features (SDBA 1974, Chau 2012).

Back Lane

The concept of backlane dates back to the same period i.e. early Penang Style, when it was supposedly used for loading unloading, and garbage disposal (Figure 2a). However, the number of stories increased from one to two, and in present days, often three or more storied CDs are also common, which results in a narrower image of the Back Lane.

Side Lane

The side lanes evolved as a concept of having a fire-break after certain length along the rows of houses. Usually the minimum width is 15’ (Figure 2b).

Service Street

Streets usually narrower than 40’ is considered as service streets. The only criteria for it traced so far from empirical observation is that they are the ones which do not have shop frontages on both sides, and usually works as a separator from collector streets or arterial roads that boundary the CDs (Figure 2c). However, if it is wider than 40’, they may be considered as local streets though they may be located at the periphery of the CDs (Figure 3a).

Local Street

They are the main streets inside CDs with a minimum of 50’ width (for residential, it is 40’), if shops are on one side (Figure 3b). If shops are on both sides, the minimum width should be 66’. However, since there must be some access points to the CDs, local streets evolving from such access may have extra width to ease the traffic (Figure 3c).

Collector Street

Collector streets are the ones that boundaries the CDs, and give access to them at strategic points. Usually they are separated from service streets at the periphery of the CDs by landscape or pedestrian walkways.

Figure 2: a) Back Lane, b) Side Lane, c) Service Street at periphery (Source: Authors)

Figure 3: a) Local Street with shops at one side, b) Local Streets with shops at both sides, c) Wider Local street having connected with the access point of the district from collector street (Source: Authors)

Boundary

Those CDs on an arterial road (primary or secondary) usually having bigger catchment area are usually separated by secondary arterial roads or collector streets from the residential areas at their back. Relatively smaller CDs are usually located on secondary arterial roads that are separated from neighboring residential areas by service streets. For ribbon type development, serving mainly the residential areas at its back may face primary of secondary arterial roads with service streets usually separating them from

the arterial roads. However, at the back, they are usually separated from the residential area by service streets. For the Shopping Streets, again it can be on collector streets or even on arterial roads with or without service roads separating them from arterial road. The scope of the study are the CDs which are on the arterial roads separated by service streets at the front, and separated from the neighboring residential areas either by collector streets or services streets.

Layout

The traditional courtyard planning with an internal staircase has also been modified. Separate staircases leading to upper floors are common these days, as they give options to rent the upper floors separately, both as offices or as residences of SOHOs.

Land use

There is no apparent policy on land use. Once the owners are handed over their property from the developers, they can apply for a business permit on particular land use. Practically, it includes almost all kind of activities. However, depending on location, some particular activities might be concentrated on particular areas. For example, there can be concentration of car related shop lots, or a concentration of restaurants depending on historical development of that district (Chau 2012).

The primary industries have gradually given way to businesses like manufacturing and retailers. At present days, tertiary industries such as service oriented businesses are also dominant (Figure 4).

Figure 4: Tertiary industries are in abundance in CDs (Source: Authors)

Method and Sample Selection

Vibrancy, in this study, is operationally defined as the intensity of people i.e. the number of people present per unit area per unit time. The people were also divided into the categories related to their necessary, optional and social activity (Table 1). Unit area was identified as a group of three to four shop lots operationally defined as ‘gates’ (Figure 5). The reason behind choosing a gate instead of a one shop lot is that the width of one shop lot appeared to be too narrow to become a definite generator of pedestrian activity. In total 48 gates were observed that covered 178 shop lots. The number of people is calculated as the number in front of one gate along duration of twenty four hours.

It was difficult to track the pedestrian in front of ground floor shop lot who were actually moving to upper floors through the staircases in between shop lots. Moreover,

there were a big number of vacant shops and stores in upper floors, which were not considered as generator of pedestrian activity. Therefore, there was little chance that pedestrian activities at shop front are generated by the land use patterns of upper floor. However, there were still some notable land use patterns in the upper floors, especially the institutions. Therefore, both floors were included as part of one gate.

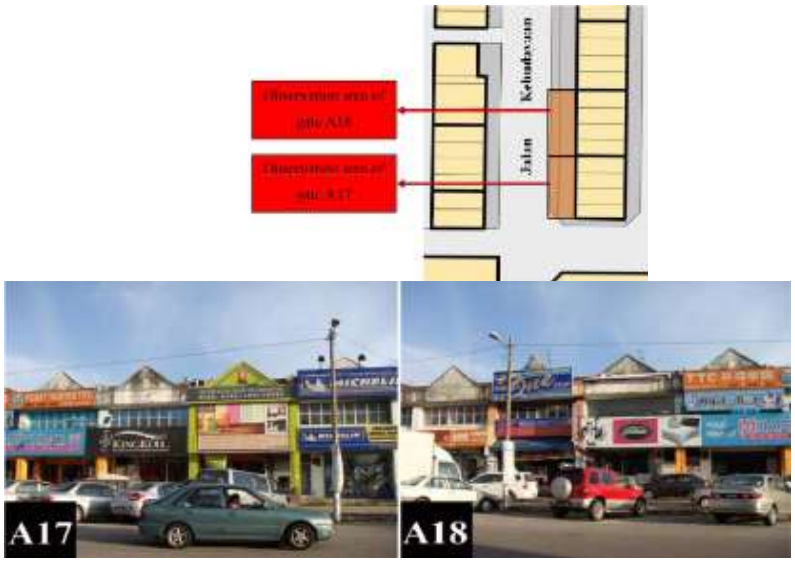

Figure 5: Shop lots and Gates (Source: Authors)

Land use was divided into twelve categories in order to reduce the number of item variables. The actual activity is listed in Table 2. Their locations were shown in figure 6 and 7.

Street elements were categorized into three. Firstly, the Infrastructure facilities like electrical supply furniture, lampposts etc. which were not exactly related with pedestrian activity. Therefore, they were not included in this study. Secondly, there were necessary facilities such as kiosks, canopies, bus stops, signage, auto pay machines etc. which can attract pedestrian to use the walkways for a shorter time period, and operationally defined as short-term-stop street elements. Finally, the secondary facilities such as benches, canopies, designed planter boxes, shades etc. which might attract people to stay there for a relatively longer period of time and therefore operationally defined as long-term-stop street elements (Table 3).

Taman University, one of the busiest CDs in the city of Johor Bahru (JB), had been chosen as the case study. It is bounded by Jalan Pendidikan, a primary arterial street in Skudai, JB, at the front, and by Jalan Kebudayaan, a secondary arterial street at the back that separates it from the residential area (figure 1). There are two major 'local' streets as the main feeder to the district (Jalan Kebudayaan 6, and 16). Service streets separate the district from the arterial roads. There are a total of 450 shop lots inside Taman University with variety of land use. However, for the study, 178 shops at each floor on the two major local streets were considered. The other shops were on service streets and considered to have less busy activities, and therefore not considered in this study.

Table 1: List of Pedestrian Activities

Necessary	Walking
Optional	Standing, Waiting, Smoking
Social	Sitting, Chatting, Eating

Table 2: List of mixed Land use patterns

Residential	Townhouses, Squatters
Wholesale	Food and beverage, Home appliances, Vehicle accessories/equipment, Fashion /dresses/bag
Retail outlet	Mini market /supermarket/shopping complex, Groceries (sundries), Home appliances
Accessories and specialized commercial	Book store, Stationery/printing, Bakery, Furniture shop, Electrical shop, Jewelries, Toys shop, Fishing equipments, Sport equipment, Shoes shop, Watches shop product and services, Fashion / dresses, Hardware, Window curtain and fabrics, Carpet, Bridal goods & decorative items, Record shop, Art gallery/handicraft, Antique shop, Wine shop, Car /motorcycle accessories, Movies shop, Show Room, Key and Accessories shop
Restaurant/ Cafe	Restaurant, Food court/ hawker centre, Bar, Coffee shop + Cafe
Business and professional services	Clinic/ Pharmacy, Chinese medicine shop, Bank, Financial centre/loan centre, Insurance centre, Money changer, Hair Salon / beauty centre, Home appliances repair shop, Tailor shop, Audio repair shop, Photography shop, Massage, Music and Dance learning
Religious institution	Mosque / Musolla/ Chinese temple
Institution	Association, Office, Educational training center
Accommodation	Hotel/service apartment/motel/boutique hotel, Hostel
Entertainment	Internet cafes, snooker
Workshop	Workshops and Vehicle's Repair Centre
Store	Warehouse / store
Vacant	Vacant premises/lot

Table 3: List of Street elements

Short-term-stop elements	Kiosks, Signage, Recycle bin, Post box, Auto pay machines
Long-term-stop elements	Benches, Canopies, , Food court, Railings

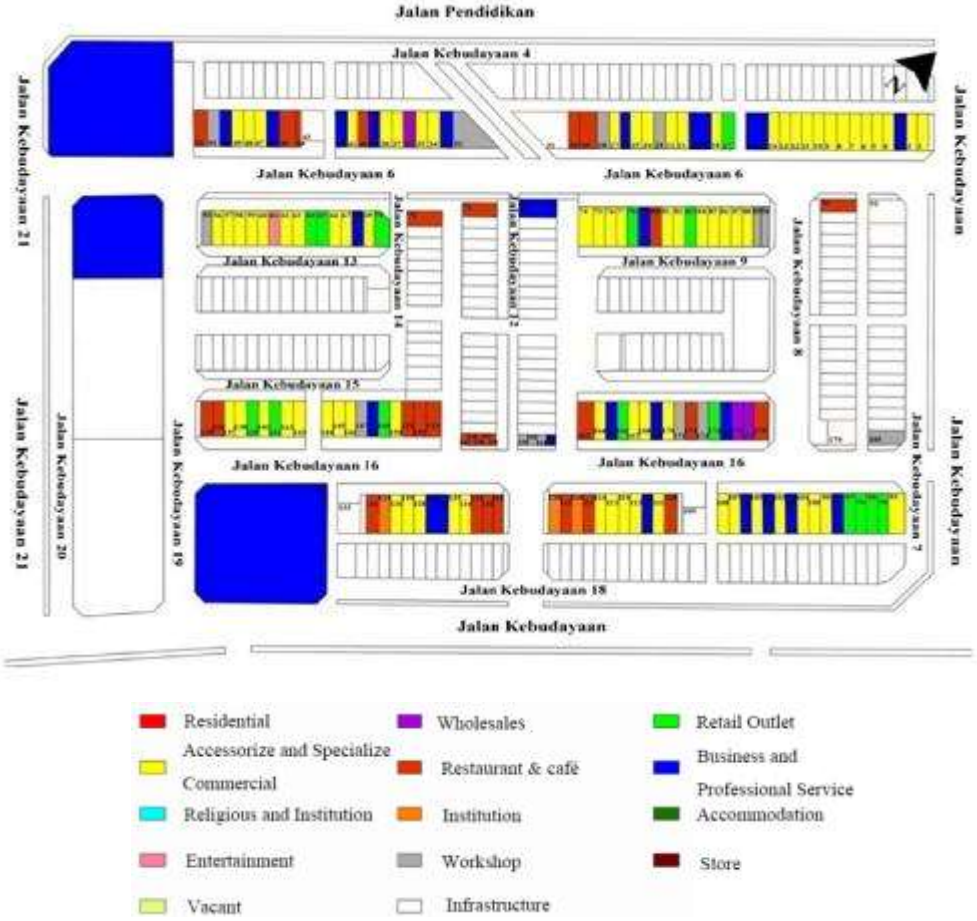

Figure 6: Ground Floor Land use pattern (Source: Authors, MPJBT 2012)

Figure 7: First Floor Land use pattern (Source authors, MPJBT 2012)

Exploratory factor analysis was performed with varimax rotation in order to manifest the constructs. The twelve land use patterns and vacant land were the item variables under the independent variable 'Land Use'. The the two types of street elements were the item variables under the independent variable 'Street Element'. Lastly the three types of activities were used as the item variables under the dependent variable 'Pedestrian Activity'. However, those land use patterns with less than 0.1 mean score were removed from the factor analysis, and the 'vacant land' item variable was also removed (Table 4), as they were assumed to have less impact on pedestrian activities. Since, pedestrian activity is the dependent variable, any factor which did not have any item variable for pedestrian activity was not considered as a valid factor. After manifesting the constructs from the strength of factor loading, that was kept at a minimum of 0.3, correlation and regression analysis was performed to estimate the coefficients of the land use patterns and street elements on pedestrian activity.

Results and Discussion

Descriptive Analysis

The summary of the variables show the mean values and their descriptions in order to have an idea about the sample (Table 4). A value of less than 0.10 has been assumed to have less impact on the pedestrian activity, and therefore, those land use variables were omitted from the analysis (un-bold ones), and the remaining eight (8) were considered for analysis.

Table 4: Summary of the variables

Variables		**Descriptive**	**Mean (%)**
Street Name		0=Jalan Kebudayaan 6 1=Jalan Kebudayaan 16	0.46
Land Use	**Residential**	**0= No, 1= Yes**	**0.27**
	Wholesale	0= No, 1= Yes	0.04
	Retail Outlet	**0= No, 1= Yes**	**0.23**
	Accessories and Specialized Commercial	**0= No, 1= Yes**	**0.71**
	Restaurant/Café	**0= No, 1= Yes**	**0.40**
	Business and professional services	**0= No, 1= Yes**	**0.54**
	Religious institution	0= No, 1= Yes	0.06
	Institution	**0= No, 1= Yes**	**0.48**
	Accommodation	**0= No, 1= Yes**	**0.17**
	Entertainment	0= No, 1= Yes	0.06
	Workshop	**0= No, 1= Yes**	**0.21**
	Store	0= No, 1= Yes	0.50
	Vacant	0= No, 1= Yes	0.44
Street Element	Short-term-stop (STS)	0= nil, 1= 1-4, 2= 5-8, 3= 9-12, 4= 13-16	2.10
	Long-term-stop (LTS)	0= nil, 1= 1-10, 2= 11-100, 3= >101	1.10
Activity	Necessary: Walking	0= nil, 1= 1-100, 2= 101-200, 3= 201-300, 4= 301-400, 5= 401-500, 6= >501	1.19

	Optional: Standing, Waiting, Smoking	0= nil, 1= 1-100, 2= 101-200, 3= 201-300, 4= 301-400, 5= 401-500, 6= >501	1.29
	Social: Sitting, Eating, Resting	0= nil, 1= 1-100, 2= 101-200, 3= 201-300, 4= 301-400, 5= 401-500, 6= >501	1.58

Factor Analysis

KMO value was found to be 0.711 with a significance of .000 showing adequacy of data. From the six (6) developed factors with an Eigenvalue set at 1, four (4) were removed as they did not have any item from pedestrian activity, which was the dependent variable. The remaining two factors suggested there might be relationship between themselves (Table 5). The item variables remained for consideration were Accessories, Restaurants, Residential, Business/ specialized commercial activities, and Workshops for land use patterns; Long-term-stop street elements; and all three types of pedestrian activities. Therefore, correlation and regression analysis were necessary to find their underlying relationship.

Table 5: Exploratory Factor Analysis

		factors	
		1	2
Land Use Pattern	**Residential**		**0.451**
	Wholesale		
	Retail outlet		
	Accessories and Specialized Commercial	**0.649**	
	Restaurant /cafe	**0.869**	
	Business and professional services		**0.433**
	Religious		
	Institution		
	Accommodation		
	Entertainment		
	Workshop		**0.346**
	Store		
	Vacant		
Street Element	**Short-term-stop street elements (Necessary)**		
	Long-term-stop street elements (Secondary)	**0.803**	
Pedestrian Activity	**Walking (Necessary)**		**0.758**
	Standing (Optional)	**0.818**	
	Sitting (Social)	**0.648**	

Correlation Analysis

Correlation analysis was carried out to test the strength of association between all the item variables with factor loading more than 0.3, in order to find out any significant relationship. Correlation was done in two steps. First, the 'total' pedestrian activity (summation of people engaged in all three activities) was correlated with the five Land Use patterns and one Street Element (Table 6). Then the three pedestrian activities were separately correlated with the Land Use patterns and the Street Element again (Shaded in Table 6). As expected, 'Accessories' and 'Restaurant' Land Use patterns, as well as Long-term-stop Street Elements had very strong association with the total number of pedestrian activities (shown in Bold), and therefore were considered as the major puller of pedestrian activity. In terms of item-wise pedestrian activities, again as expected, 'Accessories' and 'Restaurant' Land Use patterns, and Long-term-stop Street Elements showed strong association with Optional (Standing, Chatting etc.) and Social (Sitting,

Eating etc.) activities, but not with the necessary activity (Walking). Therefore these Land Use Patterns appeared to be capable of holding people for a considerable period of time. However, a significant negative correlation between Accessories and Restaurants suggested that usually they were not located closely. A significant negative correlation between Accessories and Long-term-stop street elements, and a significant positive correlation between Restaurants and Long-term-stop street elements also reinforced that statement, as Long-term-stop (LTS) Street Elements were mainly related with restaurant related activities. A less significant ($p < 0.05$) relationship between Business activities with Optional activities (standing, chatting) suggested that business activities had some contribution to the pedestrian activity as well. However, the other Land Use patterns from the factor analysis (Residential, and Workshop) failed to show any significant association with any kind of pedestrian activity, and even Business activities did not show significant relationship with necessary activity (walking), with which it shared the same factor.

Table 6: Correlation Analysis (Coefficients and level of significance)

	Resi	Acce	Rest	Busi	Work	LTS	Nece	Opt	Soc	Total
Residential	-	.185 .209	.178 .227	-.004 .979	-.197 .179	.118 .424	.166 .259	-.018 .905	-.124 .400	-.009 .951
Accessories	.185 .209	-	**-.512**** **.000**	.238 .104	-.122 .408	**-.459**** **.001**	.169 .251	**-.556**** **.000**	**-.469**** **.001**	**-.512**** **.000**
Restaurant	.178 .227	**-.512**** **.000**	-	-.110 .455	-.205 .161	**.654**** **.000**	-.054 .713	**.629**** **.000**	**.407**** **.004**	**.534**** **.000**
Business	-.004 .979	.238 .104	-.110 .455	-	-.146 .323	-.237 .104	.202 .169	*-.301** *.038*	-.160 .278	-.237 .105
Workshop	-.197 .179	-.122 .408	-.205 .161	-.146 .323	-	-.239 .102	-.102 .491	-.193 .189	-.070 .638	-.268 .105
LTS	.118 .424	**-.459**** **.001**	**.654**** **.000**	-.237 .104	-.239 .102	-	.005 .976	**.598**** **.000**	**.403**** **.004**	**.549**** **.000**
Necessary	.166 .259	.169 .251	-.054 .713	.202 .169	-.102 .491	.005 .976	-	*-.312** *.031*	-.184 .211	-.098 .509
Optional	-.018 .905	**-.556**** **.000**	**.629**** **.000**	-.301* .038	-.193 .189	**.598**** **.000**	-.312* .031	-	**.712**** **.000**	**.850**** **.000**
Social	-.124 .400	**-.469**** **.001**	**.407**** **.004**	-.160 .278	-.070 .638	**.403**** **.004**	-.184 .211	**.712**** **.000**	-	**.671**** **.000**
Total	-.009 .951	**-.512**** **.000**	**.534**** **.000**	-.237 .105	-.268 .105	**.549**** **.000**	-.098 .509	**.850**** **.000**	**.671**** **.000**	-

Regression Analysis

Since there were more than one independent variable, it was necessary to develop regression equations in order to find the contribution of each one on the dependent variable while acting together. There were four independent variables left for consideration (i.e. Accessories, Restaurant, Business, and LTS Street Element). Restaurants appeared to be the most dominant one from correlation analysis. Therefore, two regression equations were conducted. The first one showed the effect of restaurant on pedestrian activity, and the second one showing the effect of all the four variables together on pedestrian activity. The second equation showed a marked improvement in the adjusted R^2 values suggesting that, though restaurant was the single most significant crowd puller, the model worked even better with the other significant contributor co-existing together (Table 7).

	R^2	Adjusted R^2	F	Significance
Only Restaurant	0.285	0.269	18.323	.000
All four Independent Variables	0.416	0.361	7.650	.000

Table 7: Regression Analysis

Findings

From the analysis above, several interesting findings were drawn.

Restaurants and Accessory shops are the most significant contributors to vibrancy among different Land Use Patterns

Land use related with Restaurants and Accessories appeared to be the most significant contributors to the intensity of people in the CD. They have the ability to let people do Optional (Standing, chatting etc.) and Social activity (Sitting, Eating etc.). They not only attract people, but also attract them along a wider time zone, which is identified as from 10 am to 12 am (midnight). The Accessories Land Use patterns are usually open from 10 am – 8 am, while the Restaurants are open from 10 am – 12 am. Some of them open late and are open until 6 am, while there was one which was a 24 hour restaurant. Therefore, it seemed to be likely that together they could sustain the vibrancy along its surroundings all along day and night. However, the restaurants were positively associated with the LTS street elements such as benches, other sitting options, stay under canopies, etc., and the accessories were associated negatively. It was predictable as these Street Elements were very much related to Restaurant activities, and Accessories did not need them.

Malaysians love to dine out. Especially at night, when the hot sun gives way to a more pleasant light breezy environment, people start gathering outside restaurants (Tang and Khan 2012). Often chairs and tables are arranged well beyond the property line of the shops and occupy part of the roads. Street users (both pedestrian and vehicular) seem to be very tolerant about it and enjoy the atmosphere together. Therefore, given the fact that some of these restaurants are always active even beyond midnight, and may be one or two along the whole twenty four hours, they significantly bring people in the CDs continuously. Therefore, people are likely to have a general feeling of security around the whole area, and therefore vibrancy is expected to be sustained. Though there is no current guideline about locating a particular land use to a particular position in the block, it might be useful to think about the power of restaurants to sustain overall security and vibrancy of the district, and they can be distributed in a way that not only selected parts of the district, but all the local and service streets remain vibrant through locating restaurants at strategic points in the street blocks.

Restaurant and Accessories should not be mixed in close locations

Another interesting finding suggest that restaurants and accessories, which were the main two contributors to vibrancy, did not co-exist very close to each other, as they had negative correlations along the gates. Either by chance or not, this appeared to be a good combination because they are likely to spread the pedestrian more evenly rather than concentrating them in particular locations.

Business activities contribute to vibrancy during office hours only

The significant association with business activities and optional pedestrian activity (standing, chatting) showed that the business and professional services such as clinic, bank, hair salon etc, with their opening hours from 10 am – 8 pm can encourage people to interact in the district. It seemed that during this period people are likely to go out to carry out their needs related with these professional services, though they are unlikely to spend much time in the streets. This phenomenon however can be considered good enough to keep the district crowded, though it is limited to day time and office hours only. Therefore, they can be supplemented by restaurant activities in order to keep the districts vibrant all along day and night.

Conclusion

Vibrancy is the key to urban commercial districts. Vibrancy is the buzz created by humans, vehicles, media and such other contributors. Due to its character, commercial districts are bound to generate vibrancy spontaneously. However, many commercial districts in the past around the world have experienced periods during when this vibrancy reduced, that well have been the cause of abandonment of usage of some sections. Urban theorists have identified several key factors needed to sustain vibrancy in urban commercial districts. Taking into consideration two of them namely security and legibility, and identifying two parameters to detect them namely mixed Land Use Pattern and presence of Street Elements, this study tried to find out their contribution to vibrancy in terms of generating pedestrian and human activities in the context of Malaysia. It found that restaurants play the most significant role in keeping the district alive along twenty four hours. Accessory shops and business/ professional services also play their role albeit a bit less significant. This study finds that a combination of mixed use of these categories of land use with their location distributed along the district is necessary to keep the district vibrant. However, due to cultural tradition, restaurants are likely to play the biggest role for sustaining such vibrancy in commercial districts in Malaysia.

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References

ACC (2012), Adelaide City Council, http://www.adelaidecitycouncil.com/assets/acc/Development/planning-building/docs/mixed_use_development_guide.pdf, [Accessed on November 17, 2012].

CBD (2012), Central Business District. Available: http://www.scalloway.org.uk/sett12.htm [Accessed on November 17, 2012].

Chau L. W. (2012), Personal Interview with Chau Loon Wai, Lecturer, Department of Urban and Regional Planning, Faculty of Built Environment, Universiti Teknologi Malaysia (UTM), on October 17, 2012.

Crankshaw, N. (2009), Creating vibrant Public Spaces: Streetscape Design in Commercial and Historic Districts, Island Press, Washington DC.

Gehl, Jan. 1986. Life Between Building. Van Nostrand Reinhold, New York.

Handy, S. L., Boarnet, M. G., Ewing, R., and Killingsworth, R. E. (2002), How the built environment affect physical activity: view from urban planning. *American Journal of Preventive Medicine,* Vol. 23(2): 64 – 73.

Hillier, B., and Hanson, J. (1984), The Social Logic of the Space. London: Cambridge University Press.

Liang, J., and Sun, H. (2006), Analysis on the Spatial form and Model of the Traditional Commercial District in Chinese Cities, Huazhong Architecture, Vol 2.

Lim, J. S. H. (1993), The Shophouse Rafflesia: An Outline of its Malaysian Pedigree and its Subsequent Diffusion in Asia, *Journal of the Royal Asiatic Society*, Vol. LXVI(1): 47-66.

Mai-Lin T. B. (1998), Shophouses in Colonial Penang, *Journal of the Royal Asiatic Society*, Vol. LXXI(2): 122-136.

MPJBT (2012), *Majlis Perbandaran Johor Bahru Tengah, http://www.mpjbt.gov.my, [Accessed on November 17, 2012]*.

Owens, P. M. (1993), Neighborhood from and Pedestrian Life: Taking a closer Look, Landscape and Urban Planning, Vol 26(1-4): 115-135.

Rakhshanifar, M. (2011), Configuration vs. Attractors (Accounting Pedestrian Activity in Yazd City-Iran). Master's Thesis, University Technology of Malaysia.

SDBA (1974), act 133, Street, Drainage and Building Act 1974, http://www.agc.gov.my/Akta/Vol.%203/Act%20133%20Teks%201%20(1-50).pdf, [Accessed on November 17, 2012].

Tang, H. N., and Khan, T. H. (2012), Revisiting Strategies to enhance Social Interaction in Urban Public Spaces in the context of Malaysia, British Journal of Arts and Social Science, Vol 8(2): 198-212.

TCPA (1976), act 172, Town and Country Planning Act, The commissioner of Law Revision, Malaysia, http://www.agc.gov.my/Akta/Vol.%204/Act%20172.pdf, [Accessed on November 17, 2012].

Whyte, W. H. (1980), The Social Life of Small Urban Spaces. Washington, D.C: The Conservation Foundation.

Yee, B., and Manos, M. (2012), NextGen Housing: What Makes A Vibrant Neighborhood. http://nextgenhousing.wikispaces.com/file/view/What+Makes+A+Neighbourhood+Vibrant.pdf, [Accessed on November 17, 2012].

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Optimally Tuned Flatness Control of a Magnetic Levitation System using Particle Swarm Optimization

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Abstract—
Results from the study of the application of flatness-based feedback linearization to the magnetic levitation model of INTECO^{TM} Maglev system is here presented. The MAGLEV system dynamics studied consists of a set of third order nonlinear differential equations. Using computational techniques proposed by Levine, it is verified that the ball position is the flat output. The derived flat output is applied in the construction of a nonlinear control law used to control the levitation to timed set point levels as well as tracking a sine function trajectory. The controller gains are obtained and optimized using particle swarm optimization (PSO) with 15 particles, each having three dimensions. The simulation results compared very well with the PID controller designed by INTECO, outperforming it in some cases. Real time workshop was used to run some of the simulations in real-time in the MATLAB/ SIMULINK environment.

Index Terms—Magnetic Levitation, flatness, feedback linearization, particle swarm optimization.

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1. Introduction

APPLICATIONS of magnetic levitation systems (MLS) are increasingly getting into diverse areas including: trains, magnetic bearings, pumps, centrifuges, turbines etc. The control of magnetic levitation has evolved over the years from the linearized controls to nonlinear controls. The MLS is an impressive dynamic system and its synergetic system integrates sensors, drivers and controls making it a challenging control problem that can be used as an excellent project for use in control education [1]. Experimental models for teaching have been built and are being used in many departments of Engineering colleges to teach the principles of magnetic positioning, sensors, control and so on [2]-[4]. Magnetic levitation phenomenon is based on the principles of electromagnetism. It causes ferromagnetic objects to be levitated by the magnetic force induced by electric current flowing through the coils around a solenoid. The system is inundated with electromagnetic fluctuations and is naturally unstable [5]. The attractive force exerted on the levitated object by each electromagnet is proportional to the square of the current in each coil and is inversely dependent on the square of the gap. The simplest form of electromagnetic applications to magnetic bearing consists of a pair of opposing horseshoe electromagnets. Generally the electromagnetic coil is highly inductive and the rate of change of the current is limited [6]. This is because of magnetic field saturation. The electromagnetic force is thus nonlinear giving rise to difficulties to get closed-loop stability [7].

If the electromagnet used to suspend the object were simply operated with a fixed amount of current, it would not be able to maintain any kind of control over the position of the object. If the object were too close to the electromagnet, it would be pulled right up to it. If it were too far away from the electromagnet, it would fall to the floor. There would be no way to adjust or compensate for the slight variations that take place in order to maintain the object at a fixed distance from the electromagnet [8]. The system is both inherently nonlinear and open-loop unstable. This has led to the use of feedback control to stabilize the system.

Many authors have applied the analog lead compensator using classical frequency response design to control a one-dimensional magnetic levitator [5]. Methods for feedback control design typically use a linearized model of the system, but for bearing applications, it's highly nonlinear properties can limit the performance of the overall system. [9] Described a nonlinear control system for a magnetic bearing designed using a combination of feedback linearization and backstepping concepts implemented with a floating-point digital signal processor. The author in [10] designed negative feedback and phase-lead controllers to stabilize a levitation system. Several other control methods had been used to stabilize the MLS.

In this paper the flatness-based feedback linearization approach is applied to control the MLS through stabilization and tracking. Differential Flatness allows a feedback linearization strategy in which system states are defined as functions of the system flat output and its higher order derivatives. If the flat output or any variable linked to it is measureable then the states can be completely parametrized and subsequently used to implement the control law. But first the system has to be shown to possess a flat output or in other words be flat [11]. In this concept, the feedback law is constructed as a function of the flat output and its derivatives up to the order of the system control plus one on which the loop is closed. The gain structure of the closed loop control law possesses characteristics that enable the system performance to be optimized. The paper

presents the investigations carried out by optimizing the system control gains using the particle swarm optimization approach. Simulations show the efficacy of the flatness-based control in stabilizing and tracking object trajectories of the magnetic levitation system.

After the introduction in Section 1, the paper discusses the maglev model used in Section II. In Section III the flat output is computed while the particle swarm optimization algorithm used to optimize the controller gains is presented. Section IV discusses the simulations done in non-real time and real time regimes on MATLAB. Conclusions are given in Section V while in Section VI the references are given.

The Magnetic Levitator Model

The model development of the magnetic levitation is based on the system developed by INTECO^{TM} for the purpose of teaching. The system block diagram is shown in Fig. 1. The INTECO maglev system is a complete laboratory tool for studying classical control techniques, real time control and signal analysis. It is a single degree of freedom levitation system. The system is configured to run real-time experiments executed in the MATLAB/Simulink environment using the real time workshop and real time workshop target toolboxes. It is also equipped with maglev hardware and a dedicated DSP card for real-time implementations.

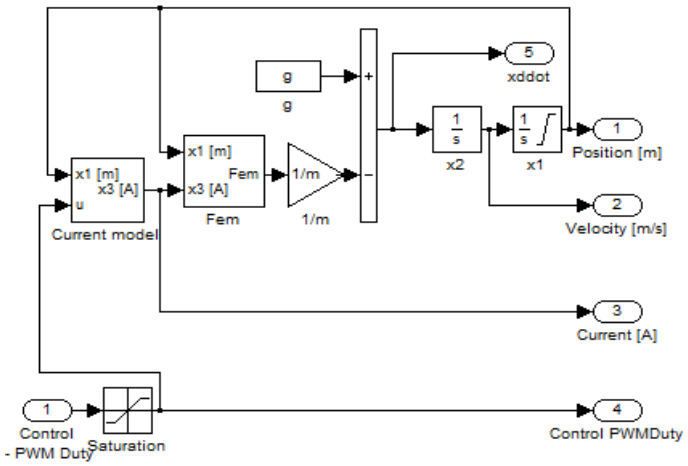

Fig. 1 Block diagram of INTECO™ maglev model.

Since the purpose is to implement the flatness-based controller using this model, a third order non linear open loop unstable dynamical system. In the model development, INTECO used empirical analysis to model control of the current that goes to the electromagnet. The resulting linear relationship is found to be a straight line $i(u) = au + b$ with a dead zone. The constants a and b are determined from the experimental data. The system dynamics are described in (1) – (3).

$$\dot{x}_1 = x_2$$

$$\dot{x}_2 = g - \frac{1}{m} x_3^2 \left(\frac{f\_p_1}{f\_p_2} \right) e^{\left(\frac{-x_1}{f\_p_2} \right)} \quad (1) \quad (2)$$

$$\dot{x}_3 = (k_i u + c_1 - x_3) \frac{1}{\left(\frac{p_1}{p_2} \right) e^{\left(\frac{-x_1}{p_2} \right)}} \quad (3)$$

Where g is gravitational force, m is mass of object, f_p_1, f_p_2, p_1, p_2, k_i, c_1 are system constants.

Flatness-Based Feedback Controller

The system

$$f(\dot{x}, x, u) = 0 \quad (4)$$

with $x \in R^n$ and $u \in R^m$ is differentially flat if one can find a set of variables called flat output;

$$y = h(x, u, \dot{u}, \ddot{u}, ..., u^{(r)}) \quad (5)$$

$y \in R^m$ and system variables,

$$x = \alpha(y, \dot{y}, \ddot{y}, ..., y^{(q)}) \quad (6)$$

and control,

$$u = \beta(y, \dot{y}, \ddot{y}, ..., y^{(q+1)}) \quad . \quad (7)$$

Fig.2 illustrates the basic feedback linearization loops.

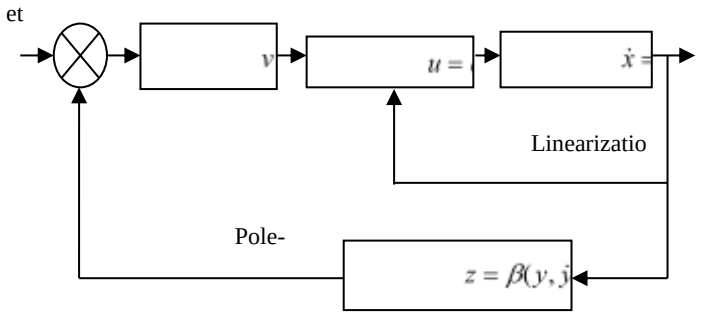

Fig. 2: Structure of flatness based Feedback Linearization.

Flat output

Given the dynamics (1)-(3), the flat output can be determined using Levine's method [12]. Applying the implicit function theory and eliminating the dynamics with control, the variational equation is given by:

$$d\ddot{x}_1 - a\,e^{\left(\frac{-x_1}{f-p_2}\right)} x_3^2\, dx_1 - a\,e^{\left(\frac{-x_1}{f-p_2}\right)} x_3^2\, dx_3 \qquad (8)$$

Where, $a = \frac{1}{m}\left(\frac{f\_p_1}{f\_p_2}\right)$.

The polynomial matrix will therefore be

$$p(f) = \begin{bmatrix} \frac{d^2}{dt^2} - a\,e^{\left(\frac{-x_1}{f-p_2}\right)} x_3^2 & -a\,e^{\left(\frac{-x_1}{f-p_2}\right)} x_3^2 \end{bmatrix} \begin{bmatrix} dx_1 \\ dx_3 \end{bmatrix}$$

or compactly

$$p(f) = \begin{bmatrix} A & -b \end{bmatrix} \begin{bmatrix} dx_1 \\ dx_3 \end{bmatrix} \qquad (9)$$

Where $A = \frac{d^2}{dt^2} - a\,e^{\left(\frac{-x_1}{f-p_2}\right)} x_3^2$ a polynomial and $b = -a\,e^{\left(\frac{-x_1}{f-p_2}\right)} x_3^2$.

Using Smith's algorithm for the manipulation of polynomial matrices, there must exist $V \in Left\ \ Smith\ \ (P(F))$ and or

$U \in Right\ \ Smith\ \ (P(F))$ such that $V\,P(F)\,U = (I_m, 0_{n-m,m})$

Therefore the following right Smith steps are performed to obtain U.

$$\begin{bmatrix} A & -b \end{bmatrix} \begin{bmatrix} 0 & 1 \\ -\frac{1}{b} & \frac{1}{b}A \end{bmatrix} = \begin{bmatrix} 1 & 0 \end{bmatrix}, \qquad (10)$$

From $\hat{U} = U \begin{bmatrix} 0 \\ I_1 \end{bmatrix}$, $\hat{U} = \begin{bmatrix} 1 \\ \frac{1}{b}A \end{bmatrix}$, generate Q such that $Q\hat{U} = \begin{bmatrix} 1 & 0 \\ \frac{1}{b}A & -1 \end{bmatrix} \begin{bmatrix} 1 \\ \frac{1}{b}A \end{bmatrix} = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$ as required [12]. Therefore,

$$Q\,dx = \begin{bmatrix} 1 & 0 \\ \frac{1}{b}A & -1 \end{bmatrix} \begin{bmatrix} dx_1 \\ dx_3 \end{bmatrix} \qquad (11)$$

Such that the first line reads $dy = dx_1$ which gives $y = x_1$ the flat output, while the second line is identically equal to zero from (9) showing the flatness of the system dynamics.

Control Law

From the computed flat output the construction of the control law follows from the following compensator.

$$\begin{aligned} y &= x_1 \\ \dot{y} &= \dot{x}_1 = x_2 \\ \ddot{y} &= \ddot{x}_1 = \dot{x}_2 \\ \dddot{y} &= \dddot{x}_1 = \ddot{x}_2 = u_L \end{aligned} \tag{12}$$

Since $\dot{x}_2$ equals (2), from $\ddot{x}_2$ we obtain

$$x_3 = \left(\frac{m(g - \dot{x}_2)}{\frac{f\_p_1}{f\_p_2} e^{\frac{-x_1}{f\_P_2}}} \right)^{\frac{1}{2}} \tag{13}$$

and from $\dot{x}_3$, the control law is computed as

$$u = x_3 - c_1 + \frac{1}{2} \left(\frac{m\ddot{x}_2 + \left(m(g - \dot{x}_2)\right) \frac{1}{f\_p_2} \dot{x}_1 M_p}{\left((m(g - \dot{x}_2))^{\frac{1}{2}} \left(\frac{f\_p_1}{f\_p_2} e^{\left(\frac{-x_1}{f\_P_2} \right)} \right)^{\frac{1}{2}} \right)} \right) \frac{1}{k_i} \tag{14}$$

where $M_p = \frac{p_1}{p_2} e^{\frac{-x_1}{p_2}}$

The linear control from (12) is given by

$$u_L = -k_1(\delta - \delta^*) - k_2(\dot{\delta} - \dot{\delta}^*) - k_3(\ddot{\delta} - \ddot{\delta}^*) \tag{15}$$

The gains k_i are chosen such that the linear time invariant error dynamics

$$e^{(3)} = -k_1 e - k_2 \dot{e} - k_3 \ddot{e} \tag{16}$$

where $e^{(j)} = \delta^{(j)} - (\delta^*)^{(j)}$ are stable. To compute the gains, (15) can be rewritten as a Hurwitz polynomial to

$$s^3 + k_3 s^2 + k_2 s + k_1 = 0. \tag{17}$$

The closed loop characteristic polynomial of a third order equivalent system is given in terms of the natural frequency and damping ratio by

$$(s^2 + 2\xi\omega_n s + \omega_n^2)(s + \beta) \tag{18}$$

such that comparing (17) and (18) gives

$k_1 = \beta\omega_n$, $k_2 = 2\xi\omega_n\beta + \omega_n^2$, $k_3 = \beta + 2\xi\omega_n$

Implementation of Particle Swarm Optimization Tuning of Flatness-based Controller (FEC)

The PSO uses a pseudorandom algorithm to search the solution space of an optimization problem. First proposed by Kennedy and Eberhart, it makes use of the inference that the social behavior of birds requires them to flock together and migrate from place to place. It therefore makes use of a collection of possible solutions called particles whose individual velocity and position are updated according to two basic expressions. The current position of each solution particle is constantly compared with the previous ones and the best is used along with the groups' best solution particle to determine the next direction of search, thereby narrowing the search space using the following relations [13].

$$v_i(t+1) = wv_i(t) + c_1\, rand*(x_{pi}(t) - x_i(t)) + c_2\, rand*(x_{Gb} - x_i(t)) \quad (19)$$

$$x_i(t+1) = x_i(t) + v_i(t+1) \quad (20)$$

(19) and (20) are used to update the particles' velocity and position at each iteration. x_{pi}, x_{Gb} represent each particle's personal best solution and the populations' best solution respectively. w, c_1, c_2 are the inertia constant, and two positive numbers referred to as the cognitive and social acceleration constants respectively. These PSO parameters have to be chosen to ensure fast and accurate convergence of the PSO. *Rand* is a random number with uniform distribution in the interval [0, 1]. A fitness function is designed for optimal selection of feedback gains.

The fitness function which is used to update the particles' velocity and position in this study is the square of the area under the curve of the object's position trajectory during stabilization and is given by:

$$J = \int_{t_1}^{t_2} |e(\tau)|^2 d\tau < \varepsilon \quad (21)$$

Where $e = (\theta_t - \theta_{ref})$ The controller gains are tuned using the PSO algorithm with 15 particles, each having three dimensions corresponding to the feedback gains k_1, k_2, k_3. Table 1 gives the PSO parameters and computed gains after 300 iterations for n particles.

TABLE I
PSO PARAMETERS

n	*w*	c_1	c_2	v_{min}	v_{max}	*iteration*		
			15	0.6-0.8	2	2	-30	30	300

The optimized gains are given by
$k_1 = 4306.4,\ \ k_2 = 709.3136,\ \ k_3 = 29.2527$

Simulation Results

Fig. 3 gives the PSO fitness after 300 iterations showing convergence at the 155 iteration to a set of gains. The gains are applied to the feedback law to simulate the system for different set points of the ball position. Fig 4 shows the stabilization of the position for a ball set-point of 0.006 m. The corresponding control applied, the current drawn by the electromagnetic coil to maintain the set-point and the corresponding velocity are shown in figs. 5-7, for a ten second simulation of the maglev system.

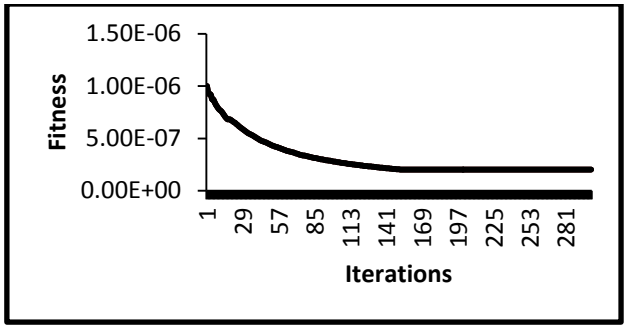

Fig. 3 Typical Fitness plot for 300 iterations

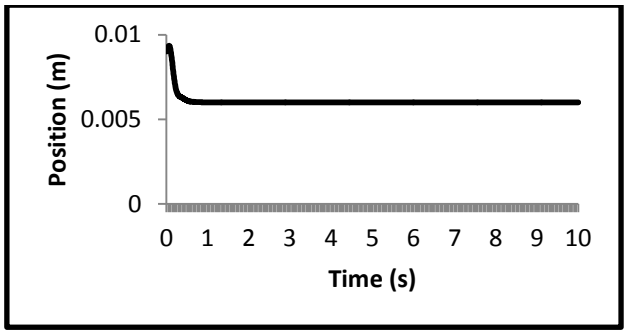

Fig. 4. Ball position for a ten second simulation

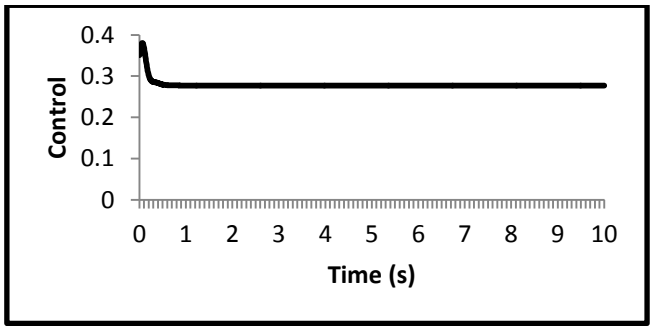

Fig. 5. Control to stabilize the ball position for a ten second simulation

The ball position was initially at an arbitrary position of 0.0092m before reaching set point in 0.5s. The control effort initially rose to a peak before dipping to the steady state as set point is reached. The current needed to stabilize the ball at set point followed the trajectory of the control effort decreasing as the ball position decreased. The transient velocity rose and decreased to steady state in 0.5s.

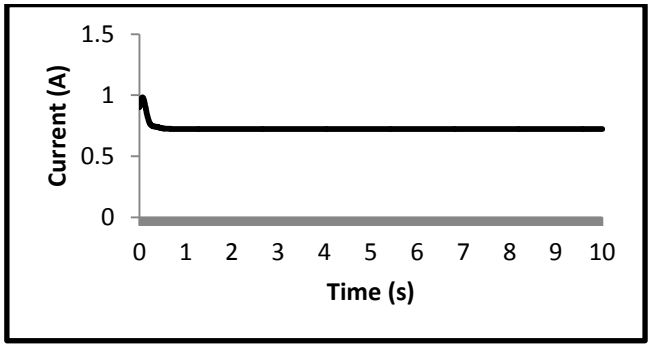

Fig. 6. Current to drive the electromagnet during levitation for a ten second simulation

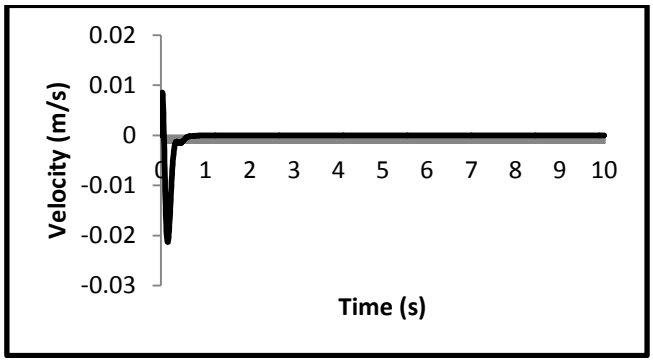

Fig. 7. Velocity showing the transient dip before stabilization of the ball position for a ten second simulation

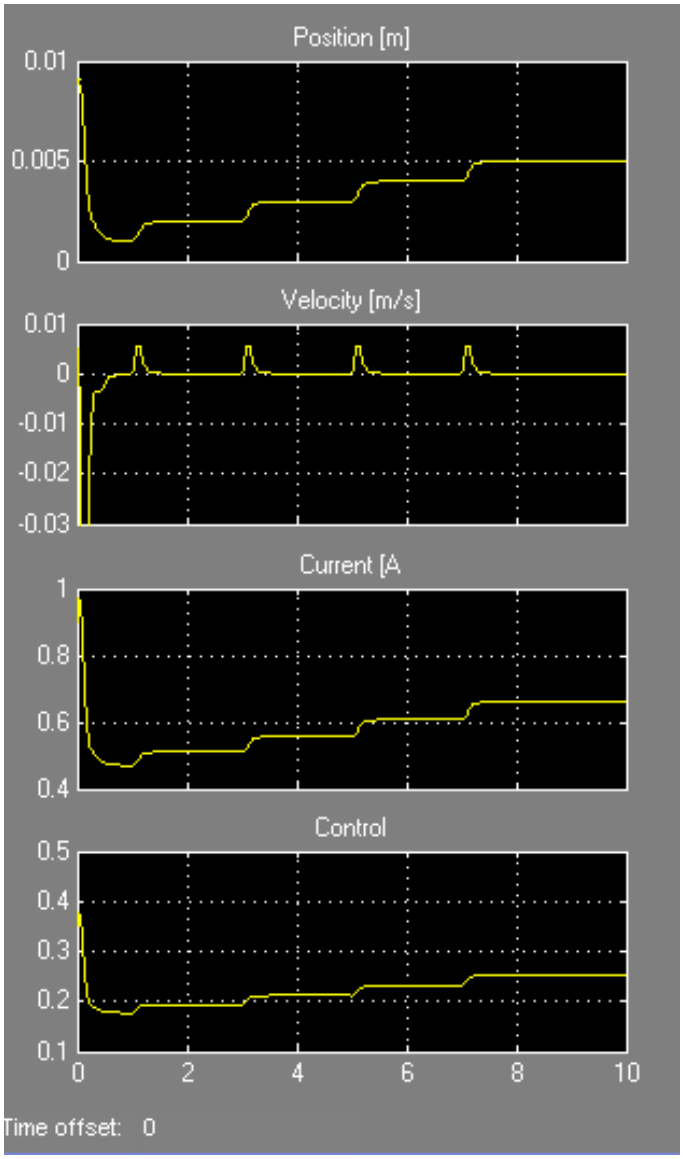

Fig. 8 Response to input [.001, .002, .003, .004, .005] mm using the Flatness Based controller.

Figs. 8 -11 show the response of the system to ascending and descending set point levels depicting the climbing up and down of a staircase. This task seems to be a challenging control task as can be seen by the sloppy and noisy response of the PID controller used on the same system. The PID controller shows difficulty stabilizing the steps of the input function as seen in the oscillations that appear at the initial set points and the step transitions. Notice that the oscillations in the ascending mode drastically reduce with time.

The flatness based controller did not show the same behavior for the ascending and descending set point levels as seen in figs. 8 and 10. The system modes induced during the sharp transitions are modeled in the nonlinear control law and thus cancelled out leaving the linear part of the law to stabilize the set point responses. The feedback based controller thus adequately compensated for these variations in system.

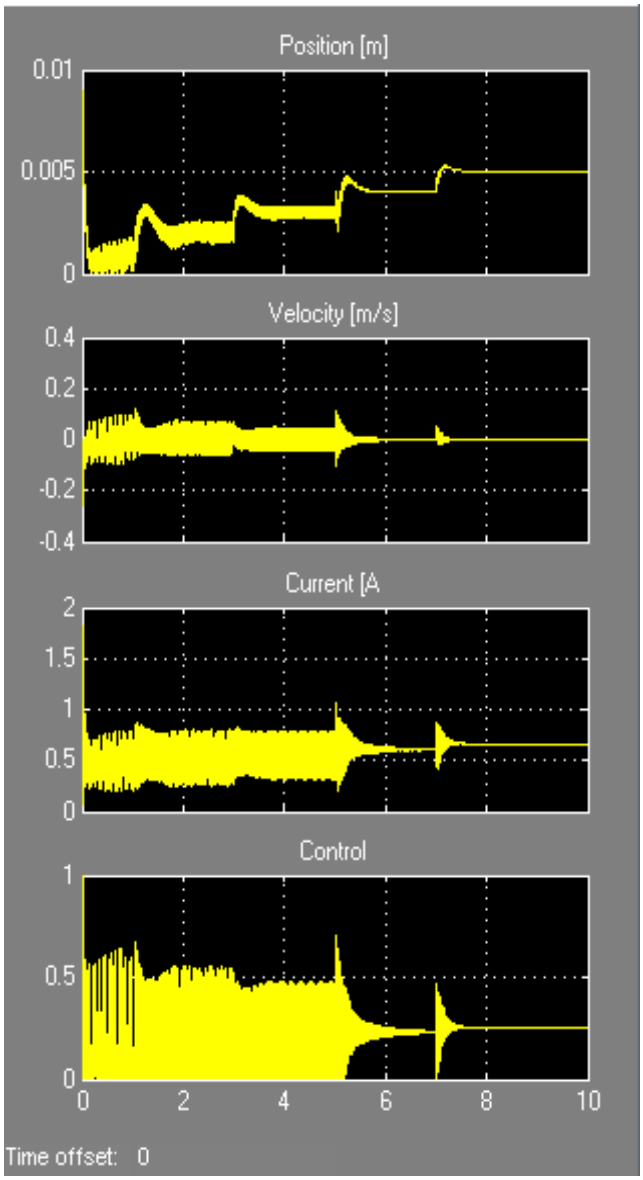

Fig. 9 Response to input [.001, .002, .003, .004, .005] mm using the PID Controller.

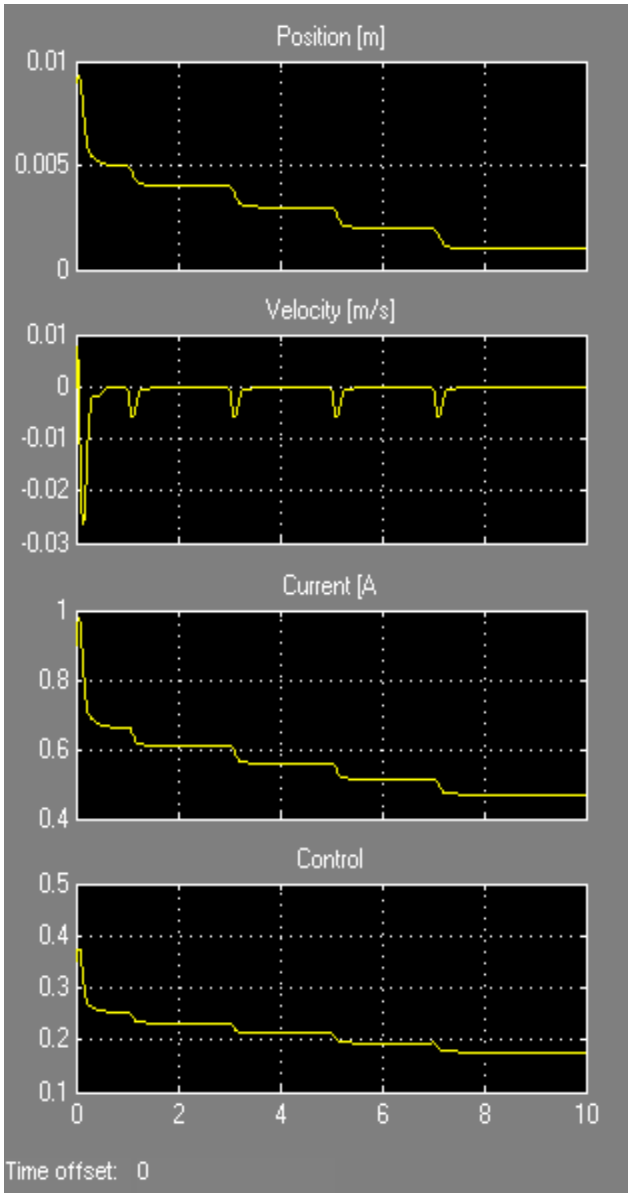

Fig. 10 Response to input [.005, .004, .003, .002, .001] mm using the Flatness based controller

Figs. 12 and 13 shows both the PID and flatness controller controlling the smooth sinusoidal transitions of the ball position. It is noteworthy that the PID gains were designed by INTECO for a specific set point and sinusoidal response and therefore maintained smooth transitions of the sine signal. Notice the larger swings of the PID Control signal and actuating current of the electromagnet. Studies of other systems show that the flatness controller gives a strong first swing control and as well improves stability margin of the system.

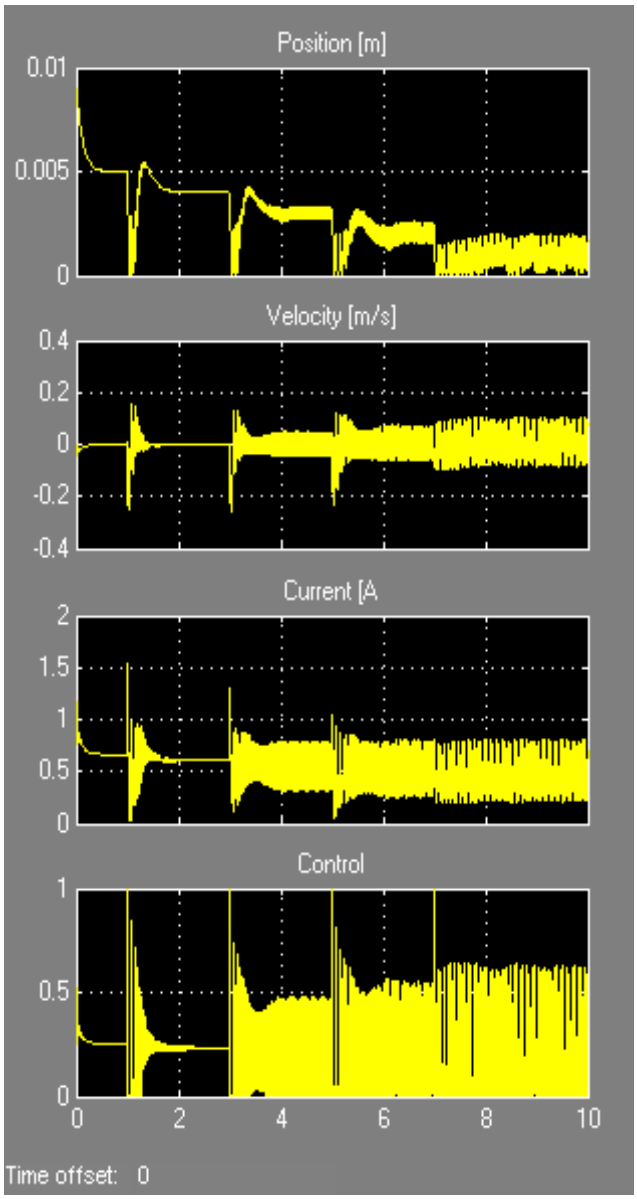

Fig. 11 Response to input [.005, .004, .003, .002, .001] mm using the PID controller

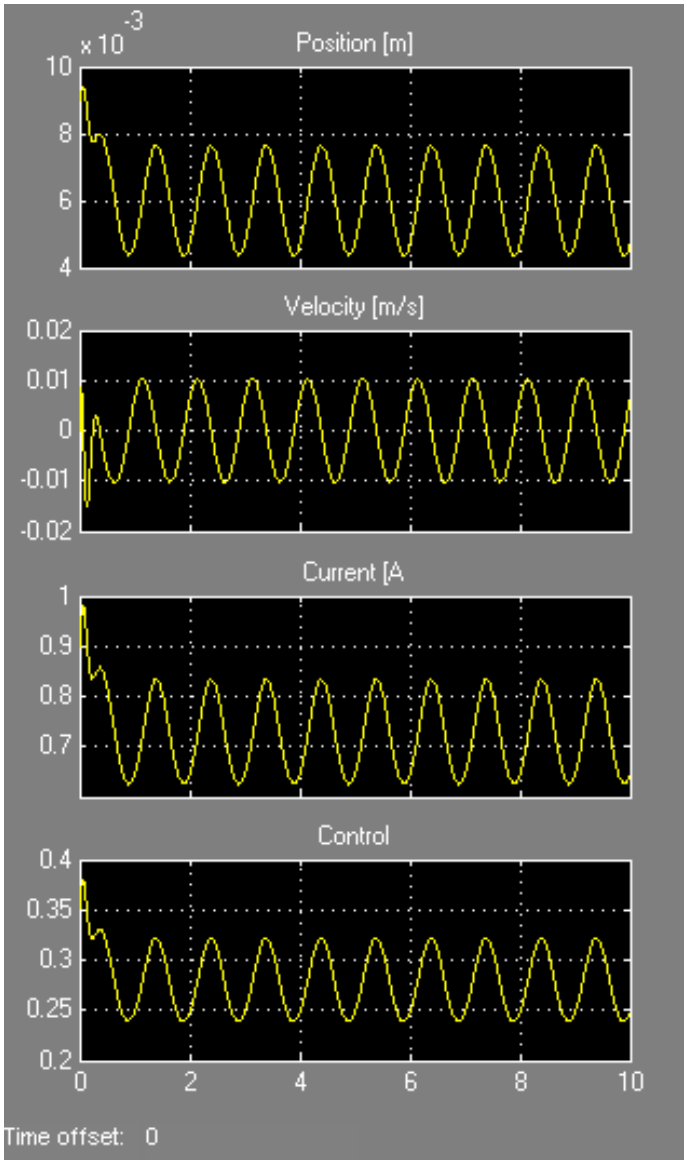

Fig. 12 Response to sinusoidal excitation using the Flatness based controller.

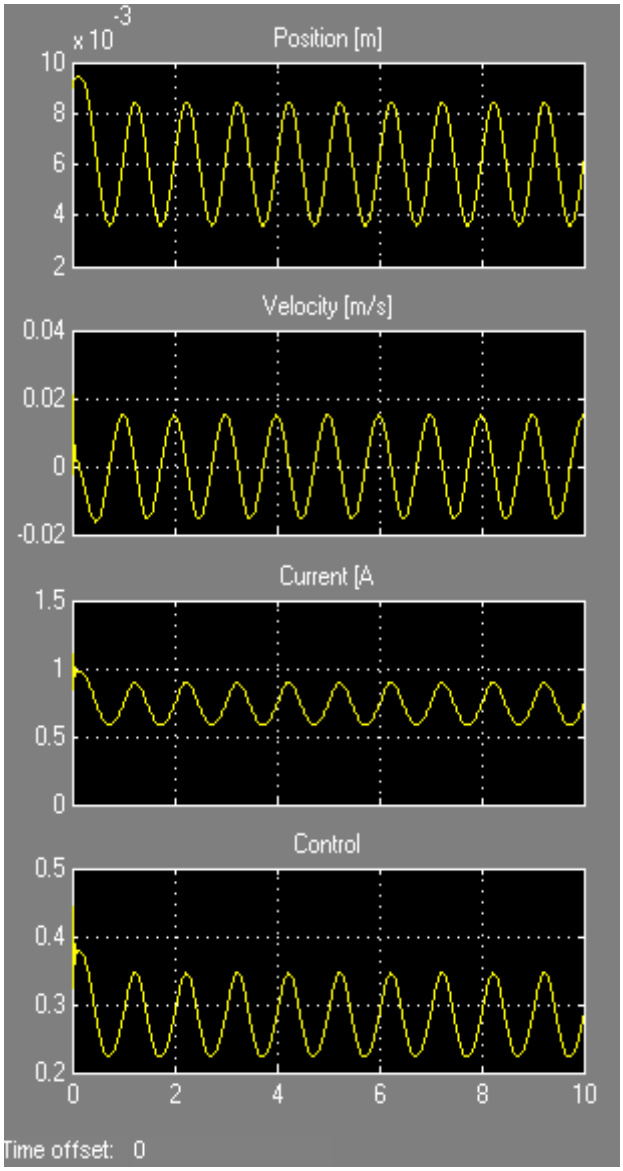

Fig. 13 Response to sinusoidal excitation using the PID controller.

Simulation done using MATLAB Real Time Workshop toolbox shows the response to tracking a sinusoidal input in real time as shown in fig. 14. The tracking was captured for the first 10 seconds showing delay in position tracking as a result of real time constants due to the computation of the tracking position.

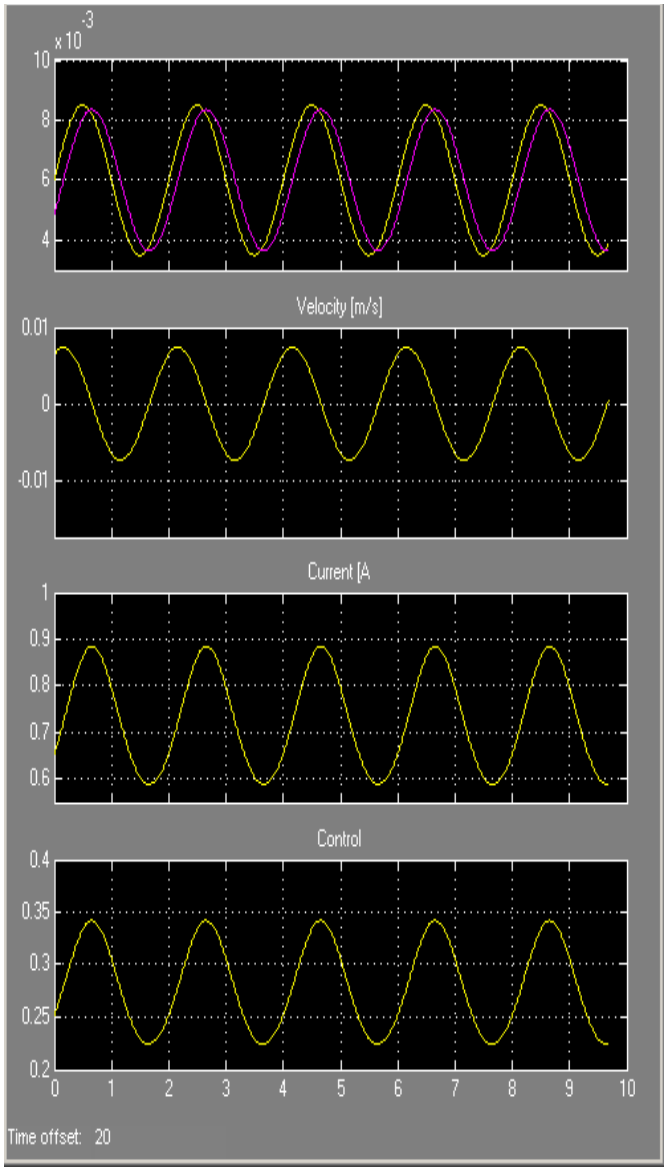

Fig.14. Real time tracking performance simulation in MATLAB for an input $2e^{-3}\sin t$ using the Flatness controller

Conclusion

The dynamics of a magnetic levitation system considered in the paper possess a flat output on which the control law used to stabilize the system was constructed. The control law was designed and applied to the system to stabilize the ball position to a set point and subsequently to ascending and descending set point. Both control schemes stabilized the ball but the PID showed some oscillations because of un-modeled dynamics which was adequately taken care of by the feedback controller. The flatness-based feedback and PID controllers performed satisfactorily well tracking a smooth sine function. The flatness controller also performed satisfactorily in real time tracking when simulated with Matlab Real Time Workshop toolbox to track a sinusoidal input.

Further research work is ongoing towards the hardware design and implementation of a simple MAGLEV plant using different control strategies as well as the flatness-based controller on the FPGA platform in the near future.

References

[1] Jen-Hsing Li, (2007) "Fuzzy Supervisory Control Of A DSP-Based Magnetic Levitation System" *Asian Journal of Control*, Vol. 9, No. 1, pp. 64-67.

[2] John M. Watkins and George E. Piper (2003) "An Undergraduate Course in Active Magnetic Levitation: Bridging the Gap", *Proceedings of the 35th Southeast Symposium on System Theory,* pp 313 - 316.

[3] Katie A. Lilienkamp and Kent Lundberg (2004), "Low-cost magnetic levitation project kits for teaching feedback system design" *American Control Conference.*

[4] S.C.Mukhopadhyay, C. Gooneratne and G. Sen Gupta (2004), "Magnetic Bearing : An Integrated Platform for Teaching and Learning" *2nd International Conference on Autonomous Robots and Agents* December 13-15, Palmerston North, New Zealand.

[5] Zhenyu Yang, Gerulf K.M. Pedersen and Jorgen H. Pedersen (2008). Model-Based Control of a Nonlinear One Dimensional Magnetic Levitation with a Permanent-Magnet Object, Automation and Robotics, Juan Manuel Ramos Arreguin (Ed.), ISBN: 978-3-902613-41-7

[6] Carl Knospe and Emmanuel Collins (1996) "Special Issue on Magnetic Bearing Control" *IEEE Transactions on Control Systems Technology*, Vol. 4, No. 5

[7] Jos´e Jaime da Cruz, Anselmo Bittar, Eduardo Alves da Costa and Roberto Moura Sales (2004) "Control And Optimization of The Electromagnetic Suspension Operation of A Maglev Vehicle". *ABCM Symposium series on Mechatronics,* vol 1, PP 150-**158**

[8] Rick Hoadly "Home-Built Magnetic Levitator" Experiments with magnetic levitation 2008, http://www.coolmagnetman.com

[9] John Y. Hung, Nathaniel G. Albritton, Fan Xia "Nonlinear control of a magnetic bearing system" (2003) *Science Direct Mechatronics* 13 621–637

[10]Jianxin Tang (2007) "Magnetic Levitation Systems Using Analog and Digital Phase-Lead Controllers" *American Society for Engineering Education Conference.*

[11]Fliess M., Lévine J., Martin Ph., and Rouchon P. (1999) "A Lie-Bäcklund Approach to Equivalent and Flatness of Nonlinear Systems", *IEEE Transactions on Automatic Control, 38: 700-716.*

[12] J. Lévine. (2003) Revised (2006) “On the Necessary and Sufficient Conditions for Differential Flatness” *Electronic print, Digital Library for Physics and Astronomy,* Harvard-Smithsonian center for Astrophysics, (arXiv: math/0605405v).

[13]Y. Del Valle, G.K. Venayagamoorthy , S. Mohagheghi, J.C. Hernandez , R.G. Harley (2008), "Particle Swarm Optimization: Basic Concepts, Variants and Applications in Power Systems", *IEEE Transactions on Evolutionary Computation, Vol. 12, Issue 2,* pp. 171 – 195.

[14]C. Yan, G.K. Venayagamoorthy, K. Corzine, "Implementation of a PSO based Online Design of an Optimal Excitation Controller" (2008), *IEEE Swarm Intelligence Symposium,* St. Louis, MO, USA, September 21-23.

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Plants capacity to accumulate and remove trace metals from wastewater

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Abstract
Major environmental and human health problems are due to the toxicity of the metals accumulated in different compartments of the ecosystems. Four aquatic species; unicellular alga *Chlorella sp.* and macrophytes floating as well as emergent plants (*Lemna minor, Phragmites communis* and *Typha latifolia*) were examined for their bioaccumulation of essential (Mg, K, Ca, Mn, Fe, Ni, Cu, Zn), no essential (Co, Al), and toxic metals (Cr, Pb). This investigation showed that, these plants have the capacity in removing metals from the environment and also could accumulate the various metals in different manner. Beside this study is reflected the different impact of trace metals over alga and macrophytes, by their effect on metabolism process of chlorophyll (*a*, *b*), total amino acids and percentage of proteins.

Keys words: Trace metals, Bioaccumulationm *Chlorella sp., Lemna minor, Phragmites communis, Typha latifolia,* Chlorophyll (*a*, *b*), Total amino acids, Percentage of proteins.

Introduction

The urban activities, industrial and agricultural are the most leading causes of the water pollution, by rejecting many organic and inorganic pollutants. This type of pollutants may have an impact on human health by direct ingestion of plants and animals or consumption of contaminated water.

Plants materials exhibit a great potential as biosorbents for the removal of water pollutants. Unlike organic pollutants in water, metals are not degraded through biological processes and their removal is required for water remediation (Cheng et al., 2002; Boutemedjet and Hamdaoui, 2009).

Microalgae are one of the most important organisms in our ecosystem because they are the main primary producer and the base of the food chain; are characterized by their rapid growth rates and ubiquitous distribution in natural environments and they show greater sensivity to environmental variation (Rama, 2001).

Macrophytes being an important component on the aquatic ecosystem not only as food source of aquatic invertebrates but also as an efficient accumulator of heavy metals. They are unchangeable biological filters and play an important role in the maintenance of the aquatic ecosystem (Peletier et al., 2002). The common duckweed *Lemna minor* is potentially useful as an indicator of pollution because of its ability to integrate and rapidly monitor the pollutant's variation in the water. Moreover, they tolerate instable environmental conditions and exhibit, sensitivity to metal toxicity (U.S. EPA, 1985b, St-Cyr et al., 1997). The interaction of dissolved metals with biological surfaces such as cell membranes can affect the transport, chemistry, bioaccumulation, and toxicity of metals. Biological surfaces are the more important substrate for metal binding in lakes and, in some cases, dissolved metal concentration are controlled by adsorption to settling biological surfaces (Dirilgen, 2001).

Materiel and methods

Various tests were performed on a green alga *Chlorella sp.* and macrophytes*; Lemna minor Phragmites communis* and *Typha latifolia* taken from five sites (S1, S2, S3, S4, S5) which located in the region of Wadi Athmenia, located in the Algerian eastern along the rivers or spilled several wastewater discharges.

1- Assays of trace metals:

The trace metals were analyzed in plants sampling in five sites using atomic absorption ICP according to a method described by [NFX31-147(1996), NF EN ISO 11885 (1998)].

2- Dosage of physiologic and biochemical parameters

2-1- The concentrations of chlorophyll *a* and *b* were measured by spectrophotometer Shimadzu 120-02 (Arnon, 1949).

2-2- The amino acids and the percentage of proteins were analyzed by the method according to (CD 98/64/EC, 1998).

Statistical analysis

Different tests are carried out in order to highlight the effect of toxicity of these trace metals and their interaction on the evolution of the photosynthetic activity and the metabolism process of these species.

Results

Results showed considerable differences in trace metals accumulation ($p<0.05$), and their bioaccumulation in aquatic microphyte *Chlorella sp*, and macrophytes*; Lemna minor*, *Phragmites communis* and *Typha latifolia* (Figures a, b, c, d, e) was very interesting, especially that these species were collected from identical sites as the water is being used for irrigation, except the site number one which is located upstream of the agglomeration.

The higher mean concentration of metals was found in *Chlorella sp.* for chromium and cobalt (0,161., 0,111 $mmolkg^{-1}$ DW) respectively, *Lemna minor* for potassium and manganese (635,94; 7,43 $mmolkg^{-1}$ DW) respectively, *Phragmites communis* for iron, zinc and aluminum (49,10; 1,43; 69,09 $mmolkg^{-1}$ DW) respectively, and *Typha latifolia* for magnesium, calcium, nickel, copper and lead (177,2; 671,46; 0,95; 0,47; 0,10 $mmolkg^{-1}$ DW) respectively.

For the content of chlorophyll *a* and *b*, the mean values as shown in (figure f) was for *Chlorella sp* (164,4; 49,54 $\mu gg^{-1}FW$) respectively, *Lemna minor* (382,02; 133,08 $\mu gg^{-1}FW$) respectively, *Phragmites communis* (172; 69,92 $\mu gg^{-1}FW$) respectively, and *Typha latifolia* (175,25; 62, 44 $\mu gg^{-1}FW$) respectively.

For amino acids, the results revealed that the high mean value was for *Lemna minor* (16,7 $g100g^{-1}$ WF), then *Phragmites communis, Typha latifolia* with (9,38 and 9,39 $g100g^{-1}$ WF) respectively, and finally for *Chlorella sp.* (5,79 $g100g^{-1}$ WF) as shown in (figure g).

For the percentage of proteins the results showed that, the high mean value was for *Lemna minor* (79,69%), then *Chlorella sp.* (79,19%), *Phragmites communis* (69,13%), and finally *Typha latifolia* (65,60%) as shown in (figure h).

The relation between the accumulation of trace metals and metabolism process showed that, the high bioconcentration of metallic ions reflect the influence of urban and industrial effluents. Beside this, these species evolved different manner in response of their effect. In one hand the affinity of plant to accumulate an element than another (interaction and antagonism). In other hand, the role played by different mechanisms of biological membranes of these plants to translocate and to store them.

For *Chlorella sp*. (table1), the metallic ions (macronutrients and micronutrients) which have been played significant role ($p<,05$) were magnesium, potassium, manganese and specially nickel (r=0,62), by the increase of chlorophyll *a*, but the decrease in chlorophyll *b* content was mainly associated with the increase of copper and zinc (r=-0,53., -0,73). In other part, the sensitivity of the high levels of zinc and toxic metals; chromium and especially lead caused the increase of amino acids (r=0,69).

However, *Lemna minor* exhibited different reactions in the presence of trace metals in their area. The results (table 2) revealed that, the physiological and biochemical processes of this plant were significantly influenced by the presence of magnesium and potassium, and wasn't significant effect with calcium. But, the correlation between benefit and micronutrients contents and mechanism process revealed negative relationships with chlorophyll contents specially with cobalt for chlorophyll *a* (r=-0,99) and for total amino acids (r=-0,94), nickel for chlorophyll *b* (r=-0,97), iron for percentage of proteins (r=-0,58). Similar effects were observed with no essential (aluminum) for total amino acids (r=-0,80), and toxic elements (lead) for chlorophyll *b* (r=-0,78).

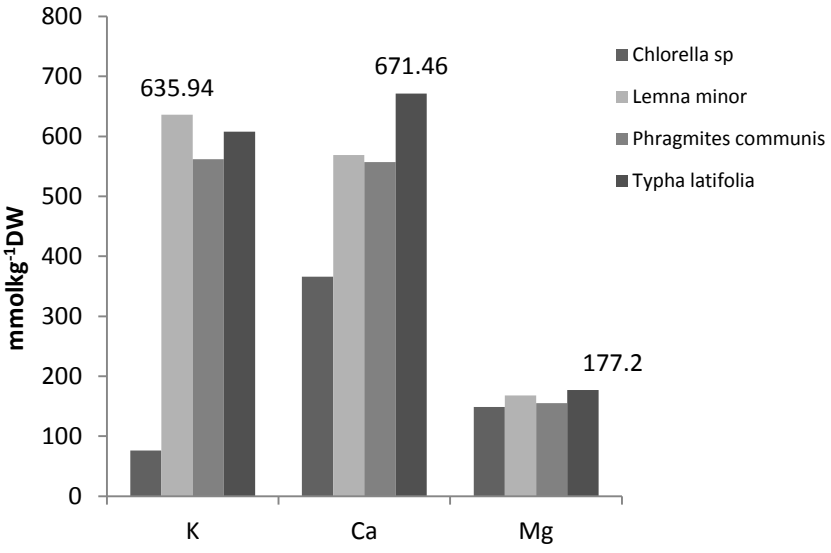
For *Phragmites communis* (table 3), the effect of magnesium was appeared significantly on chlorophyll a and chlorophyll *b* (r=0,70, 0,51). The potassium for chlorophyll *a* (r=0,69), but caused negative effect for total amino acids (r=-0,78). The decrease in the content of chlorophyll *a* (r=-0,70) and *b* (r=-0,53) caused by several effect of calcium.

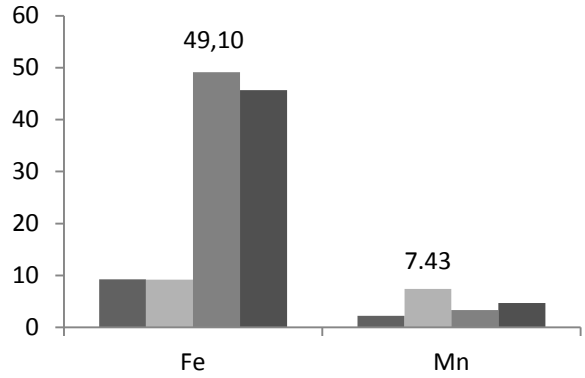
The effect of micronutrients appeared positively for manganese on total amino acids and specially for percentage of proteins (r=0,88), nickel for chlorophyll *a* (r=0,63), and negatively for the zinc on percentage of protein (r=-0,72). The effect of aluminum was appeared positively on total amino acids and especially on the percentage of protein (r=0,72).

Significant effect of toxic elements was appeared with the presence of lead only, for percentage of protein (r=0,51).

The physiological and biochemical processes of *Typha latifolia* (table 4) were more sensitive particularly by the presence of calcium. The effects of magnesium is induced the increase of amino acids only (r=0,52), the potassium on chlorophyll *a* and specially *b* (r=0,91), and percentage of protein (r=0,86). Beside this, the correlation between micronutrients concentrations and metabolism process revealed positive relationships with zinc and especially manganese on chlorophyll a and percentage of protein (r=0,95), but iron and copper caused drastic effect. Aluminum was significantly correlated with the increase in total amino acids (r=0,64).

The bioaccumulation of toxic elements appeared by the effect of lead on chlorophyll *a*, percentage of protein and especially on chlorophyll *b* (r=-0,82)

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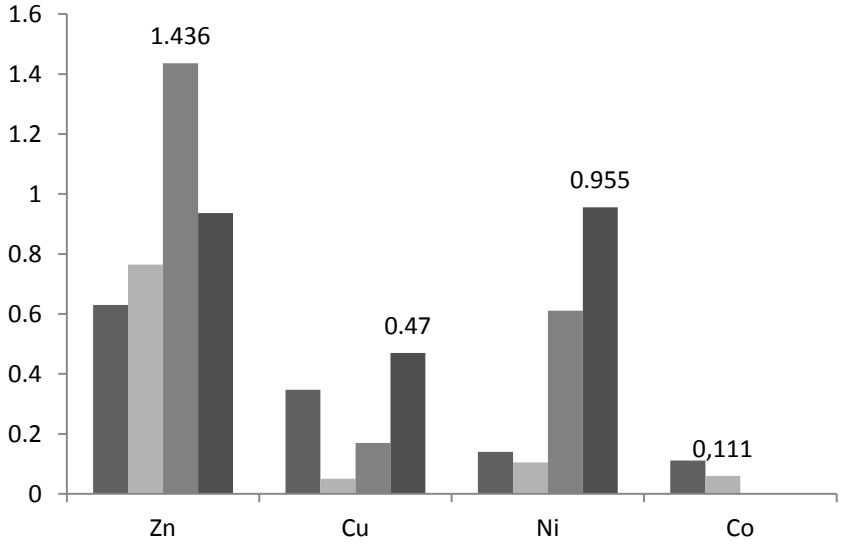
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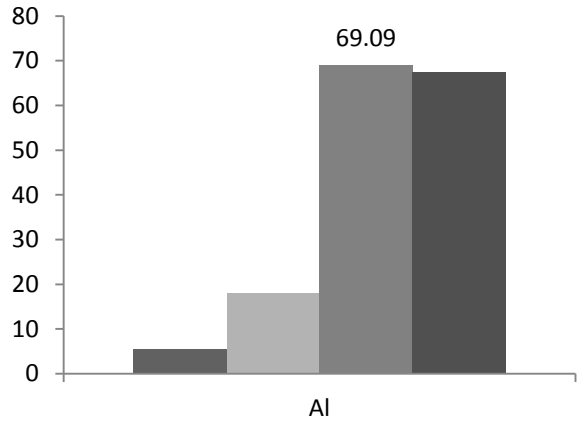
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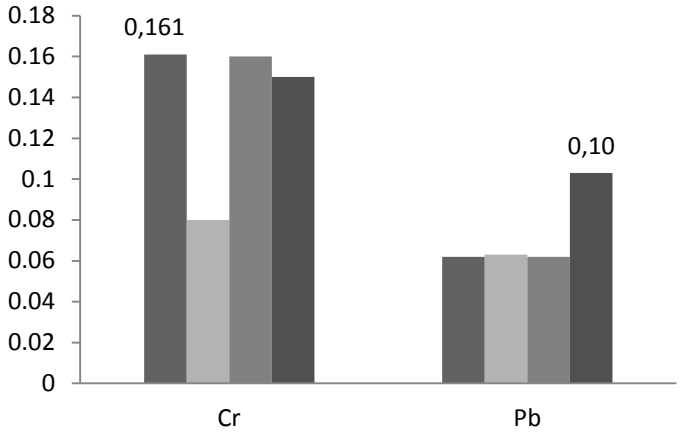
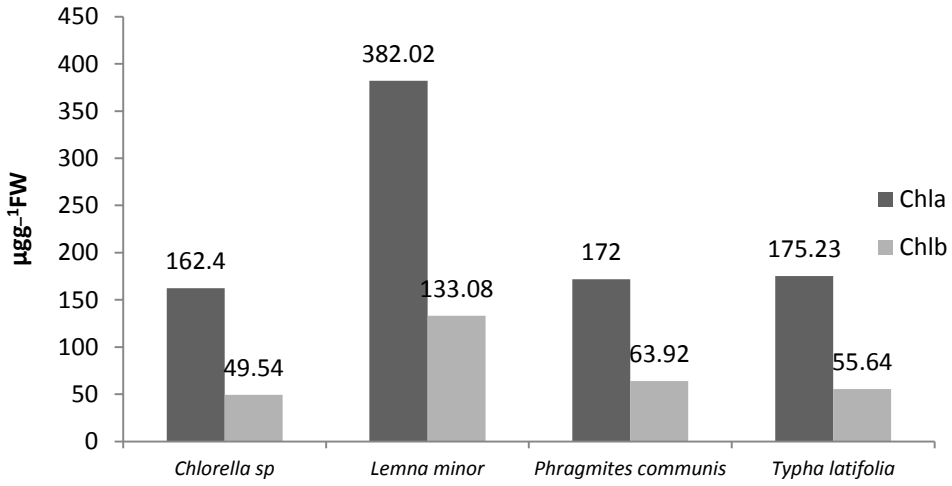
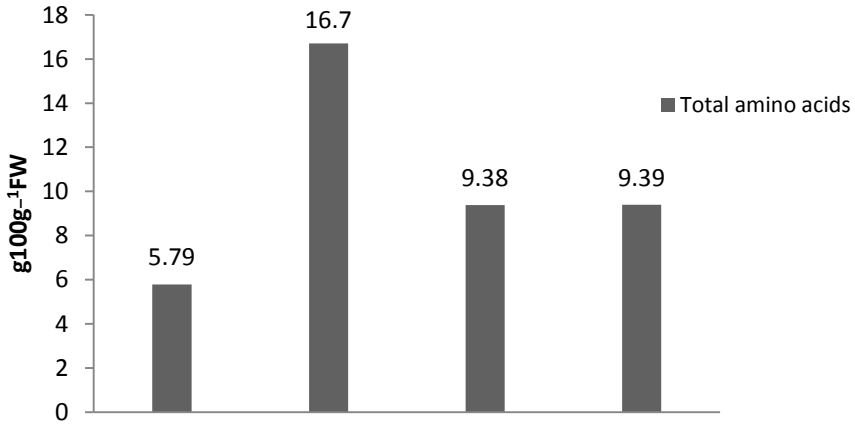
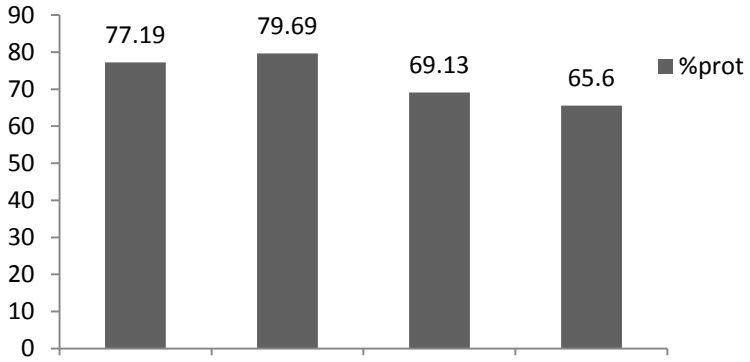


Figures a, b, c, d, e: Mean values of trace metals accumulate by *Chlorella sp., Lemna minor*, *Phragmites communis* and *Typha latifolia* in five sites of sampling







Figures f, g, h: Mean values of chlorophyll (*a* and *b*), total amino acids, percentage of proteins in Chlorella sp., Lemna minor, Phragmites communis and Typha latifolia

Tables (1, 2, 3, 4): The relation between trace metals and metabolism process of *Chlorella sp., Lemna minor, Phragmites communis and Typha latifolia*

Correlations significantly marked at p< 0,05				
Trace metals	*Chlorella sp*			
	Chl *a*	Chl *b*	TAA	%Prot
Mg	0,60	NS	NS	NS
Al	0,70	NS	NS	NS
K	0,61	NS	NS	NS
Ca	NS	NS	NS	NS
Cr	NS	NS	0,53	NS
Mn	0,50	NS	NS	NS
Fe	NS	NS	NS	NS
Co	NS	NS	0,50	NS
Ni	0,62	NS	NS	NS
Cu	NS	-0,58	NS	NS
Zn	NS	-0,73	0,56	NS
Pb	NS	NS	0,69	NS

Correlations significantly marked at p< 0,05				
Trace metals	*Lemna minor*			
	Chl *a*	Chl *b*	TAA	%Prot
Mg	0,86	0,64	0,85	0,63
Al	-0,78	-0,79	-0,80	NS
K	0,91	0,70	0,90	NS
Ca	NS	NS	NS	NS
Cr	-0,97	-0,88	-0,91	NS
Mn	-0,92	-0,94	-0,93	NS
Fe	-0,63	NS	-0,59	-0,58
Co	-0,99	-0,95	-0,94	NS
Ni	-0,97	-0,97	-0,92	NS
Cu	-0,67	-0,89	-0,64	NS
Zn	-0,72	-0,91	-0,68	NS
Pb	-0,62	-0,78	-0,58	NS

Correlations significantly marked at p< 0,05				
Trace metals	*Phragmites communis*			
	Chl *a*	Chl *b*	TAA	%Prot
Mg	0,70	0,51	NS	NS
Al	NS	NS	0,56	0,72
K	0,69	NS	- 0,78	NS
Ca	- 0,70	- 0,53	NS	NS
Cr	NS	NS	NS	NS
Mn	NS	NS	0,80	0,88
Fe	NS	NS	0,80	0,95
Co	_	_	_	_
Ni	0,63	NS	NS	NS
Cu	NS	NS	NS	NS
Zn	NS	NS	NS	-0,72
Pb	NS	NS	NS	0,51

Correlations significantly marked at p< 0,05				
Trace metals	*Typha latifolia*			
	Chl *a*	Chl *b*	TAA	%Prot
Mg	NS	NS	0,52	NS
Al	NS	NS	0,64	NS
K	0,65	0,91	NS	0,86
Ca	- 0,87	- 0,85	-0,79	-0,87
Cr	NS	NS	NS	NS
Mn	0,82	0,95	0,77	0,95
Fe	- 0,50	- 0,64	NS	- 0,59
Co	_	_	_	_
Ni	NS	NS	NS	NS
Cu	-0,94	- 0,95	-0,86	-0,97
Zn	0,60	0,87	0,50	0,82
Pb	-0,64	- 0,82	NS	-0,78

Discussion

The metals concentrations were increased from surrounding environment to these species *(Chlorella sp., Lemna minor, Phragmites communis, Typha latifolia)*, which have been showed the high potential for accumulation of elements and might be an indicators and useful in phytoremediation of aquatic systems contaminated by trace metals (Rahmoune, 1999., Ravera, 2001., Baldantoni, 2004., Peng, 2008).

However the major accumulation of different metals analysis in this study depended of many parameters based on the sensibility of plants to certain elements than others which could be developed synergetic or antagonist effects on physiological and biochemical processes.

The decrease of chlorophyll *a* and *b* contents were considered a sensitive indicator of photo inhibition in response to the bioaconcentration of metallic ions which could react with these chlorophyll (*a, b*) and caused their degradation.

This toxicity could generate many disorders by the increase of total amino acids, percentage of proteins, or by their drastic effect caused alteration and damage of metabolism process (Fargosova, 2001., Rai, 1999).

Conclusion

This study revealed that these species played a very significant role in removing different metals from the ambient environment, and often taking up elements in excess of need and can accumulate essential as well as their ability in accumulation no essential and toxic elements for concentrations many times higher than those of the surrounding environment. These species had also demonstrated a large difference in bioconcentration of trace metals; *Chlorella sp.* supported the effect of metal stress compared to the macrophytes *Lemna minor* which was so affected, that its biomass declined significantly in the sites localized especially in the downstream of the effluent, *Phragmites communis* and *Typha latifolia* by the senescence symptoms caused by the degradation of metabolism.

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References

Arnon, DI. (1949). Copper enzymes in isolated chloroplasts : poly phenol oxidase in *Beta vulgaris*. Plant Physiol, (24), 1-15.

Baldantoni, D., Alfani, P., Tommasi, P.D., Bartoli, G., De Santo, A.V. (2004). Assessment of macro and microelement accumulation capability of two aquatic plants. Environmental pollution, (130), 149-156.

Bouttemedjet, S., Hamdaoui, O. (2009). Sorption of malachite green by eucalyptus bark as a non- conventional low-cost biosorbent, Desal. Wat. Treat, (8), 201-210.

Cheng, S., Grosse, W.F., Karrenbrock, F., Thoennessen. (2002). Effeciency of constructed wetlands in decontamination of watrer polluted by heavy metals, Ecol. Eng, (18), 317-325.

Commission Directive 98/64/EC of 3 September (1998). Dosage of amino acids. Official Journal of the European communities L 257, 14-28.

Dirilgen, N. (2001). Accumulation of heavy metals in freshwater organisms: Assessment of toxic interactions. Turk. J. Chem, (25), 173-179.

Fargasova A. (2001). Phytotoxic effects of Cd, Zn, Cu and Fe o Sinapis alba L. seedlings and their accumulation in roots and shoots. Biologia Plantarium 44 (33), 471-473.

NFX31-147. (1996). Qualité des sols. Sols, sediments. Mise en solution par attaque acide. Norme Francaise. Ed Afnor, pp 299- 305.

NF EN ISO 11885. (1998). Dosage de 33 éléments par spectroscopie d'émission atomique avec plasma couplébpar induction. Norme européenne. Ed. Afnor, pp 166-185.

Peletier, E., Webb, S.M., Gaillard, J.F. (2003). Zinc and lead sequestration in an impacted wetland system. Advences in environmental research, (8), 103-112.

Peng, K., Luo, C., Lou, L., Li, X., Chen, Z. (2008). Bioaccumulation of heavy metals by the aquatic plants Potamogeton pectinatus L. and Potamogeton malaianus Miq. And their potential use for contamination indicators and in wastewater treatement. Sci.Tàt. Env, (392), 22-29.

Rai V. K. (2002). Role of amino acids in plant responses to stresses. Dept. of Biosciences, H.P. Unv. Shimla 171005, India.

Rahmoune, C. (1999). Capability of reed *(Phragmites communis*) to reduce chromic pollution of water. 3rd International symposium <<Irrigation of horticultural crops>>. 28 Jun. 02 Jul. Estoril (Portugal).

Rama, M. P., Lopez, C. H., Alonso, J.A., Vaamonde, E.T., 2001. Class III metallothioneins in response to cadmium toxicity in the marine microalga *Tetraselmis Suecica* (KYLIN) Butch. Env. Tox. and Chem, 20 (9), 2061-2066.

Ravera, O. (2001). Monitoring of the aquatic environment by species accumulator of pollutants: 2003-2004. a review. – In Ravera O. (ed): Scientific and legal aspects of biological monitoring in freshwater. J. Lmnol, 60 (1), 63-78.

St-Cyr, L., Cattaneo, A., Chassé, R., Fraikin, C. G. J. (1997). Technical evaluation of monitoring methods using machrophytes, phytoplankton and periphyton to assess the impacts of mine effluents on the aquatic environment, pp. 1-187.

U.S. EPA. (1985b). "Lemna Acute Toxicity Test".

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Plasma free thyroxin levels according to age and body weight in broiler chickens

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Abstract

The present study examined the effect of age, and body weight on plasma free thyroxin concentrations during broilers' fattening period. The trial was carried out on 60 broilers of two strains: 30 heavy fast growing broilers Arbor Acres strain and 30 lighter- weight, fast growing broilers Isa 15 strain. At 28, 35 and 42 days of age, ten birds per strain were sacrificed by decapitation. Blood plasma was separated by centrifugation and concentrations of free thyroxin were determinated by radio-immuno-assays. The obtained results revealed significant differences in free thyroxin concentration changes in blood plasma between Isa 15 strain and Arbor Acres strain. Concentrations of free thyroxin in chicken plasma gradually and statistically increase during all the experimental period in Arbor Acres strain. However, in Isa 15 strain, free thyroxin concentrations reduce statistically between 28 and 35 days of age, and then increase between 35 and 42 days of age. A positive correlation was observed between free thyroxin concentrations and body weight ($r=0.509$, $p\leq0.003$) in Arbor Acres strain. No significant correlation was noted for Isa 15 strain. These results suggest that the variations in free thyroxin concentrations during this period of intensive meat production certainly follow the intensity of production which was higher for the Arbor Acres strain. More investigations on the dynamics of free thyroid hormones concentration changes in blood plasma must be conducted in view of their great importance in poultry production.

Key words: plasma free thyroxin, broiler chickens, body weight, age, strain.

I. Introduction

The thyroid is an endocrine organ found in all vertebrates and the avian gland is similar in many respects to that of mammalian. In birds as in other vertebrates, product hormones are both thyroxin (tetra-iodothyronine or T4) and tri-iodothyronine (T3). The mechanisms of hormone synthesis and release by avian thyroid gland are essentially equivalent to those in mammals (Mc Nabb, 2000).

In homeothermic animals, the thyroid hormones are essential in the control of body temperature by stimulation of thermogenesis and regulation of basal metabolism. They increase O2 consumption and stimulate the activity of enzymes involved in metabolic regulation (Abdelatif and Saeed, 2009). Thyroid hormones have multiple effects on vertebrate metabolism. During development, they stimulate both growth and differentiation (Darras and al, 2006), and there is abundant evidence that they are very important for the hatching process in the chicken. The normal post hatch growth in birds is positively correlated with the rising of circulating T3 and T4 (Rahimi, 2005). The plasma T4 concentrations increase steadily after hatching, but T3 concentrations increase much less (Mc Nabb, 1995).

Thyroid gland synthetizes and secretes a mixture of T3 and T4. Thyroxin constitutes approximately 60% and T3 approximately 40% of the circulating thyroid hormone in the domestic birds (Biswas and al, 2010). Most of them are bound to proteins in the blood, and a part of them is free. Only a free hormone is physiologically active and its amount in blood plasma is very small (Bobiniène and al, 2010). T3 and T4 are entirely bound to plasma prealbumins and albumins. However, no avian plasma specific binding globulins could be demonstrated as in mammalian blood (Castay and al, 1978). The lack of specific carrier proteins could be the explanation on the plasma concentration of thyroid hormones in birds are 8-10 times less than in mammals (Gyorffy, 2008).

T4 makes a functional reserve of T3. In target cells, T4 is converted into T3, wich is the active hormone. The most important metabolic pathway for thyroid hormones is deiodination wich is an irreversible process. The enzymes catalysing deiodination of thyroid hormones are iodothyronines deiodinases (Darras and al, 2006). The T3 is converted from 5`-monodeiodination of T4 by type 1 iodothyronine deiodinase in the liver and kidney, by type 2 deiodinase in the brain, pituitary gland, and brown tissues, or by type 3 deiodinase in the placenta, brain and skin (Tao and al, 2006).

Adult birds of many species have blood T4 concentration in the range of 6-19 pmol/mL, and T3 concentration in the range of 0.7- 1.5 pmol/mL (Mc Nabb, 2000), showing daily variations due to an extremely short half-life (Nourmohammadi and al, 2011).

Selecting accurate methods plays a key role when determining thyroid hormone concentrations in poultry. There are various methods to determine of blood thyroid hormone concentrations such as : radioimmunoassay (RIA), enzyme-linked immunosorbent assay (ELISA), chemiluminescence immunoassay (CLIA), electrochemiluminescence immunoassay, high performance liquid chromatography, and gaz liquid chromatography (Eshratkhah and al, 2011). Of these techniques, RIA is the most sensitive and the most accurate and have been in common use for analyzing avian thyroid hormones (Mc Nabb, 2000 ; Hoshino and al, 1997).

Previous studies have examined the impact of various factors on T3 and T4 levels in birds, including species (Gonzales and al, 1999), age (Bobeck and al, 1977), energy

intake and dietary compostion (Lauterio and Scanes, 1987 ; Swennen and al, 2005), feeding regimen (De Beer and al, 2008), photoperiod (Proudman and Siopest, 2005), geographic variation (Burger and Denver, 2002), ambiant temperature (Tao and al, 2006), pathophysiologic status (Lin and al, 2008), but were limited to the total form of hormones, and to a few broiler strains.

There is no doubt about the great involvement of thyroid hormones in poultry production processes. Since, the avian thyroid gland secretes in majority thyroxin (T_4) (Darras and al, 2006), and the best marker for thyroid function is free thyroxin (Kurtdede and al, 2004) ; the present study was conducted to examine the association of age, body weight and plasma free thyroxin hormone levels in two strains of broiler chickens: Isa 15 strain and Arbor Acres strain during the fattening period.

II. Materiel and Methods

1. Animal and housing

The study was conducted in the poultry farm BENBOULAID (Constantine-Algeria). Broilers Isa 15 strain were reared from 1 to 59 days of age, and broilers Arbor Acres strain were reared from 1 to 57 days of age according to the technological recommendations for these breeds. Experiments were carried out on 60 broilers of the two strains: 30 heavy fast growing broilers Arbor Acres strain, and 30 lighter- weight, fast growing broilers Isa 15 strain. The two groups of animals were housed in two different battery brooders but subject to equivalent conditions including feeding. Chickens were fed up during the first 11 days of age with commercial starter diet, and from day 12 until the end of fattening period with commercial grower diet. The content of crude protein (%) and metabolisable energy (kcal/kg of diet) was as follows: starter diet: 22.11- 2823.75, grower period: 20.32- 2908.53. The temperature was maintained between 22 and 24°C. The animals were exposed to a light:dark cycle of 16 hours light : 8 hours dark at 21 days of age. The lighting is then increased by 2 hours each week to 22 hours light at 42 days until slaughter. Water and feed were provided ad libitum for the two strains.

2. Blood samples

At 28, 35 and 42 days of age, ten birds per strain were sacrificed by decapitation. Blood for analysis was collected from the jugular vein, and harvested into heparinized polystyrene tubes. After sampling, blood plasma was separated by centrifugation at 3,000 rpm for 10 minutes, and the obtained plasma was stored in a freezer at -20°C for later analysis.

3. Hormone assays

The concentration of free T4 was recorded by radio- immune- assay method (RIA), using the principle of labeled antibody. Samples and standards are incubated with I125- labeled monoclonal antibody specific for T4, as tracer, in the presence of a biotinylated analog of thyroxine (ligand) in avidin-coated tubes. There is a competition between the free thyroxin of the sample and the ligand for the binding to the labeled antibody. The fraction of antibody complexed with the biotinylated ligand binds to avidin-coated tubes. After incubation, the content of tubes is eliminated and bound radioactivity is measured. A calibration curve is established and unknown values are determined by interpolation from the curve. Specificity of the assay for the free T4 had

been established by the supplier. Intra and interassay coefficient of variation were 8.3% and 7.5% respectively.

4. Statistical analysis

The results were evaluated statistically by the Statview 1992- 98 SAS Institute.Inc. Data were analyzed with one way analysis of variance (ANOVA). The student's t-test was used to evaluate strain differences. Z test correlation was applied to assess the relation between free thyroxin concentrations and body weight in the two strains. Comparisons were considered significant when p values were less than 0.05.

III Results

1. Body weights

In table 1, body weights of Arbor Acres strain and Isa 15 strain at 28, 35, and 42 days of age are presented. Chickens of Arbor Acres strain were heavier in this investigation than Isa 15 strain. Their body weights were higher at 28, 35, and 42 days of age.

2. Free thyroxin levels

In the Isa 15 strain, the concentration of free T4 in 28- day- old chickens varied betwween 17.68 pmol/L and 28.84 pmol/L, averaging 20.76±3.19 pmol/L. At the age of 35 days, plasma concentration of freeT4 varied between 12.12 pmol/L and 21.55 pmol/L with a mean of 16.40 ± 2.83 pmol/L. At the end of the experience, at day 42 of life, free T4 concentration ranged between 14.98 pmol/L and 20.82 pmol/L amounting to a mean of 18.80±2.17 pmol/L.

In the Arbor Acres strain, the concentration of plasma free T4 in 28 days-old chickens ranged between 14.68 and 21.75 pmol/L, with a mean of 17.91±2,37 pmol/L. At 35 days of age, values varied between 11.61 and 21.52 pmol/L averaging 17.02±3.17 pmol/L.

In 42 day- old chickens, concentration of plasma free T4 ranged between 18.43 and 23.31 pmol/L, amounting to a mean of 21.09± 1.44 pmol/L. (Table 2)

3. Correlations

The correlation between free thyroxin and body weight using Z test is summarized in table 3. Plasma free thyroxin concentrations were positively correlated with body weight ($r=0.509$, $p\leq0.003$) in Arbor Acres strain. No significant correlation was observed for Isa 15 strain.

IV Discussion

Obtained data is in accordance with technological norms for Arbor Acres and Isa 15 strains. Arbor Acres chickens are heavy broilers selected on fast growth (Uni and al, 1996 ; Sterling and al, 2006), and Isa 15 chickens are lighter- weight fast- growing broilers (Table 1). Pavlovski and al (2009) have concluded that Arbor Acres genotype at the age of 42 days realized lower mortality, better feed conversion, higher body mass and higher realized value of production index. Abdullah (2010) has reported that genetic variation between the strains could have resulted in body weight gain variation and different body growth potential.

Selection for diverse productive parameters has also induced endocrine changes, more particularly at the levels of thyroid hormones which are closely related to avian metabolism.

This study revealed differences in free thyroxin concentration changes in blood plasma between Arbor Acres strain and Isa 15 strain. The rise of free thyroxin concentrations among the beginning and the end of the experiment was statistically significant for Arbor Acres strain. However, in Isa 15 strain, this increase was not statistically significant; free thyroxin levels reduce statistically between 28 and 35 days of age, and then increase between 35 and 42 days of age (Table 2). The increase of free thyroxin in Arbor Acres strain between 28 and 42 days of age coincided with the period in which the most rapid relative growth is observed. At this stage of development, chickens begin to accumulate enormous amounts of muscle.

Arbor Acres chickens were characterized by higher body weights at 28, 35, and 42 days of age, and a significant correlation was noted between circulating free thyroxin and body weight in this strain (Table 3). Rahimi (2005) has observed a positive correlation between body weight and plasma T4 levels, and lines differences in circulating T4 levels.

The increased T4 levels are in agreement with previous results which showed that T4 increased consistently with age in broilers and Weight Leghorns (Lu and al, 2007). Stojevic and al (2000) have reported the age dependent (3-6weeks) increase in the concentration of T3 and T4 hormone. Moravej and al (2006) have showed that in step with increase broilers age, mean concentrations of plasma T4 were increased in broilers fed on different energy and protein levels. Luger and al (2001) have concluded that plasma T4 concentrations continuously increase with age in healthy broilers.

Considering the metabolic role of the thyroid hormones in the organism, these results should be expected. The changes in relative growth rate and free thyroxin concentrations support the classical observations that thyroid hormones are necessary for growth. It is evident that thyroid hormones T3 and T4 are involved in wide range of metabolic activities influencing the growth and development of birds. The thyroid hormones are primarily involved in energy production by increasing the metabolic rate in turn heat production. Their importance is most visible in deficient animals that exhibit stunted growth and lower productivity (Biswas and al, 2010). Any reduction of physiological levels of thyroid hormones impairs the growth and development of embryos (Gregory and al, 1998).

Thyroid hormones have multiple effects on vertebrate metabolism and development. In homeothermic animals, thyroid hormones regulate basal metabolic rate and are essential for the maintenance of high and constant body temperature (Darras and al, 2000). Chicks, which are still poikilotherm (variable body temperature) at the day of hatch, gradually change into a homeothermic status (stable body temperature), when they are able to maintain their body temperature by means of their own metabolic processes (Stojevic and al, 2000).

It is generally thought that T4 is the predominant thyroid hormone in circulation, but it has little inherent biological activity, the more metabolically active thyroid hormone is T3 (Navidshad and al, 2006). Hayashi and al (2009) have showed that T4 is active and plays important metabolic roles especially in protein metabolism in chicken skeletal muscle cells. It is plausible that T4 plays major roles in the regulation of heat

production and skeletal muscle protein metabolism in animals. Because normal plasma levels of T4 is about 6 times of that of T3, T4 is then more stable in the plasma than T3.

But free thyroxin is a better marker than total thyroxin for thyroid function and is more independent from the transport capacity of plasma proteins. As T4 is the principal hormone synthesized by thyroid gland, impairment in thyroid function would directly and early lead to fall serum free T4 concentrations. Because the fixation of T4 to proteins slowed down the liver hormone catabolism, bound T4 persisted in plasma for a long time and serum T4 concentrations would be less responsive to variations in thyroid biosynthesis (Kurtdede and al, 2004). This was the reason for monitoring free thyroxin hormone concentrations in this study.

Gregory and al (1998), have demonstrated that the elevation in thyroid hormone levels necessary for hatching is probably due to increased pituitary TSH production. Thyrotropin (TSH) is a hormone that stimulates the thyroid gland to produce thyroxin and then triiodothyronine which stimulates the metabolism of almost every tissue in the body.

According to the results of this study, it appears that the variations in the thyroid hormone concentrations during this period of intensive meat production certainly follow the intensity of production which was higher for the Arbor Acres strain. A higher metabolic rate is associated with increased secretion of thyroxin, which is deiodinated to triiodothyronine in target cells. When the body has enough T3 available, any excess T4 remaining in reserve will be rendered inactive by the conversion of it into reverse T3 (rT3).

The higher profile of both T3 and T4 during early 6 weeks of age may be reflected to an increased metabolic rate, especially to energy production as well as to their involvement in the growth and development of the chickens at early age of life (Biswas and al, 2010).

Because of their great importance to the growth, especially for broiler chickens which need a great amount of energy for very short and very intensive production period, now one would expect that how important are the thyroid hormones in the development of chickens.

V Conclusion

It can be concluded that the increased secretion of thyroxin during this period of intensive meat production may be related to an increased metabolic rate especially for Arbor Acres strain. The study suggested conducting more investigations on the dynamics of free thyroid hormone concentration changes in blood plasma in view of their involvement in the growth, and their great importance in poultry production.

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References

1-Abdelatif,A and Saeed, I. (2009). Effect of altered thyroid status in the domestic rabbit (lepus cuniculus) on thermoregulation, hear rate and immunes responses. Global veterinaria 3 (36):447-456.

2- Abdullah,Y ; Al Beitawi,N ; Rjoup,M ; Qudsieh,R and Ishmais,M. (2010). Growth performance, carcass and meat quality charachteristics of different commercial crosses of broiler strains of chickens. J. of poultry science., 47 :13-21.

3- Biswas,A ; Mohan,J ; Sastry,K. (2010). Age-dependant variation in hormonal concentration and biochemical constituents in blood plasma of Indian native fowl. Veterinary Medicine International.

4- Bobeck,S ; Jastrzebski,M ; Pietras,M. (1977). Age-related changes in oxygen consumption and plasma thyroid hormone concentrations in the young chickens. Gen. Comp. Endocrinology. 31, 169- 174.

5- Bobiniene,R ; Gudavičiute,D ; Miškiniene,M. (2010). The impact of iodine on biochemecal blood parameters in laying hens. Veterinaria Zootechnika (*Vet Med Zoot*). T. 51 (73).

6- Burger,M ; Denver,R. (2002). Plasma thyroid hormone concentrations in a wintering passerine bird: their relationship to geographic variation, environmental factors, metabolic rate, and body fat. Physiological and biochemical zoology. 75(2):187- 199. 2002.

7- Castay,M ; Bismuth,J ; Astier,H. (1978).Thyroid binding proteins of duck and chicken sera. Gen. Comp. Endocrinology. 35, 491- 495.

8- Darras,V ; Verhoelst,C ; Reys,G ; Kuhn,E ; Van Der Geyten,S. (2006). Thyroid hormone deiodination in birds. Thyroid. 16 (1) : 25- 35.

9- De Beer,M ; Mc Murty,J ; Brocht,D ; Coon,C. (2008). An examination of the role of feeding regimens in regulating metabolism during the broiler breeder groxer period. 2. Plasma hormones and metabolites. Poultry science. 87 : 264-275.

10- Eshratkhah,B ; Zadeh,S ; Forouzan,V ; Parsa,A ; Ghalehkandi,J. (2011). Comparative study on the determination of serum thyroid hormones by two methods of immunoassay in broiler breeder poultry. Comp. Clinical Pathyology. 20 (4) 337-340.

11- Gonzales,E ; Buyse,J ; Sartori,J ; Loddi,M ; Decuypere,E. (1999). Metabolic disturbances in male broilers of differents strains. 2. Relationship between the throid and somatotropic axes with growth rate and mortality. Poultry science. 78 : 516- 521.

12- Gregory,C; Dean,C and Porter,T. (1998). Expression of chicken thyroid stimulating hormone β subunit messenger ribonucleic acid during embryonic and neonatal development. Endocrinology, 139(2): 474-478.

13- Gyorffy,A. (2008). Selected endocrine factors of energy metabolism. PhD thesis. Post graduate school of veterinary science. Zagreb.

14- Hayashi,K ; Kuroki,H ; Kamizono,T ; Ohtsuka,A. (2009). Comparison of the effects of thyroxine and triiodothyronine on heat production and skeletal muscle protein breakdown in chicken. J. Poultry science. 46 : 212- 216.

15- Hoshino,S ; Noda,M ; Yamamaoto,R ; Wakita,M. (1997). Radioimmunoassay for thyriod hormones in chicken serum. Bull.Fac. Bioressources. 17 : 1-5.

16- Kurtdede,A ; Asti,R ; Sel,T ; Kurtdeded,N ; Karagul,H ; Otalay,O ; Guzel,M. (2004). Effect of anti-inflammatory and immunosuppressives doses of prednisolone on serum triiodothyronine , thyroxine and free thyroxine concentrations and thyroxine morphology in the dog. Revue de Méd.Vét., 2004,155,6,324-330.

17- Lauterio,T ; Scanes,C. (1987). Hormonal responses to protein restriction in two strains of chickens with different growth characteristics. J.Nutr. 117 : 758-763.

18- Lin, H ; Decuypere,E and Buyse,J. (2008). Effect of thyroid hormones on the redox balance of broiler chickens. Asian- Australian journal of animal science, vol 21, number 6: 794- 800.

19- Lu,J ; Mc Murty,J ; Coon,C. (2007). Developmental changes of plasma insulin, glucagon, insuline-like growth factors, thyroid hormones, and glucose concentrations in chick embryos and hatched chicks. Poultry science. 86 :673-683.

20- Luger,D ; Shinder,D ; Rzepakovsky,V ; Rusal,M ; Yahav,S. (2001). Association between weight gain, blood parameters, and thyroid hormones and the development of ascites syndrome in broiler chickens. Poultry science. 80 : 965- 971.

21- Mc Nabb,F. (1995). Thyroid hormones, their activation, degradation and effects on metabolism. Conference presented as part of the 59th annual poultry nutrition.

22- Mc Nabb,F. (2000). Thyroids. In sturkie's avian physiology (fifth edition) p 461- 471.

23- Moravej,H ; Khazali,H ; Shivazad,M ; Mehrabani- Yeganeh,H. (2006). Plasma concentrations of thyroid hormones and growth hormone in Lohmann

male broilers fed on different dietary energy and protein levels. International journal of poultry science 5(5): 457-462, 2006.

24- Navidshad,B ; Shivarzad,M ; Zareshahneh,A ; Rahimi,G. (2006). Effects of feed restriction and dieatry fat saturation on performance and serum thyroid hormones of broiler chickens. Int. J. of Poultry science 5(5) : 436- 440.

25- Nourmohammadi, R ; Hosseini, M ; Saraee, H ; Arab, A. (2011). Plasma thyroid hormone concentrations and pH values of some GI- tract segments of broilers fed on different dietary citric acid and microbial phytase levels. American journal of animal and veterinary sciences 6(1): 1-6, 2011.

26- Pavlovski,Z ; Skrbic,Z ; Lukic,M ; Petricevic,V ;Trenkovski,S. (2009). The effect of genotype and housing system on production results of fatenning chickens. Biotechnology in animal husbandry. 25 (3-4) : 221-229.

27- Proudman,J ; Siopest,T. (2005). Thyroid hormone and prolactin profiles in male and female turkeys following photostimulation. Poultry science. 84 : 942-946.

28-Rahimi, G. (2005). Thyroid hormones characteristics and hepatic deiodinase enzyme activity in broiler lines selected for growth and feed conversion. Int. J. of Poultry science. 4(7) : 482- 487.

29- Sterling,K ; Pesti,G ; Bakalli,R. (2006). Performance of different broiler genotypes fed diets with varying levels of dietary crude protein and lysine. Poultry science, 85 : 1045- 1054.

30- Stojevic,Z ; Milinkovic-Tur,S ; Curcija,K. (2000). Changes in thyroid hormones concentrations in chickens blood plasma during fattening. Veterinarski archives. 70(1) : 31- 37.

31- Swennen,Q ; Janssens,G ; Millet,S ; Vansant,G ; Decuypere,E ; Buyse,J. (2005). Effects of substitution between fat and protein on feed intake and its regulatory mechanisms in broiler chickens : Endocrine functionning and intermediary metabolism. Poultry science. 84 : 1051- 1057.

32- Tao,X ; Zhang,Z ; Dong,H ; Zang,H ; Xint,H. (2006). Responses of thyroid hormones of market- size broilers to thermoneutral constant and warm cyclic temperatures. Poultry science. 85 : 1520- 1528.

33- Uni,Z ; Noy,Y ; Sklan,D. (1996). Development of the small intestine in heavy and light strain chicks before and after hatching. Br. Poultry science. 37(1) : 63-71.

Table 1. Body weights in Isa 15 strain and Arbor Acres strain (g).

	28days	35days	42days
Isa 15 strain	1211.10 ±42.64	1693.40 ±21.39	2128.50 ±34.40
Arbor Acres strain	1408.50±25.68	1984.70±36.32	2625.10 ±58.06

Table 2. Plasma levels of free thyroxin (pmol/L) in Isa 15 strain and Arbor Acres strain according to age.

	28days	35days	42days
Isa 15 strain	$20.76^{a,1}$ ±3.19	$16.40^{b,1}$ ±2.83	$18.80^{a,b,1}$ ±2.17
Arbor Acres strain	$17.91^{a,2}$ ±2.37	$17.02^{a,c,1}$ ±3.17	$21.09^{b,2}$ ±1.44

The values associated with various letters or numbers are significantly different ($p<00.05$) : letters for comparison by columns, and numbers for comparison by lines.

Table 3. Correlation between free thyroxin and body weight in Isa 15 strain and Arbor Acres strain.

	Correlation	Number	Z	P	95%inf	95%sup
FT4-body weight Isa 15	-0.217	30	-1.147	NS	-0.536	0.155
FT4-body weight Arbor Acres	0.509	30	2.917	0.003	0.182	0.735

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Microcontroller Application: Design and Construction of a Six Channel Seismograph -A Case Study

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Abstract

This case study is an application of microcontroller – as a reliable control of timing seismic signal travels, involving sampling per channel, recording and displaying their first-time brake intervals. It is a custom-built six channel refraction survey device, which consists of microcontroller unit (MCU), peripheral interface unit (PIU) and the peripherals. Its program determines the first time brake interval, of the response of geophones attached to it in a seismic geophysical survey. It accommodates up to six geophones, and detects their seismic energy impact- which is indicated by turning on a busy detecting LED; start timers; and prompts the geophones' responses. When a particular geophone responds, it stops its timer and stores the value, and when the detection is complete for the other geophones - it turns off the busy detecting LED; and turns on, a detection complete LED. When the display button is pressed, it displays the times recorded for the geophones, starting with first geophone.

KEY WORDS: Seismograph, Microcontroller, Six channels, PIC16F877, Peripherals, Time brake recorder application

Introduction

The Semiconductor Industry Association (SIA) road map, of projected technology development for this year - 2012, expect 100 million transistor per cm^2 integration, gate length of 0.035μm on a chip size of 1300mm^2. Thus, typical microcontroller has high system integration and low cost profile, as demonstrated in this case study. It uses a series of instructions encoded, as binary code groups, in Read-Only Memory, rather than the former approach of wiring standard ICs.

The MCU utilizes 40-pins microchip PIC 16F877, in controlling all the components of this instrument, with respect to 4.4MHz crystal oscillator used in clocking the microcontroller processor. The control is enabled by an approximately six hundred lines of assembly language code, uploaded into the PIC, and written to express the geophysical refraction surveying model. Its liquid crystal display, shows in six digits, results of recorded first- time –brake intervals per channel for each shot.

The PIU mainly include dual Op Amps (LM 324) for amplification, filtering and digitization of output signal, through comparator's circuits, each of which is directly linked to one register or the other in the PIC, through a corresponding pin.

The peripherals includes: the geophones and their cables; the Impact – Trigger System, which include a thick circular plate arranged on a rectangular metal sheet; and a heavy hammer for seismic energy source.

Design

2.0 Problem Definition

A fundamental concept of seismic exploration is to send into the earth a mechanical signal, which is then reflected or refracted back from boundaries between layers of its subsurface. The pure signals having some well-defined shape or characteristic are transmitted from a source and is later received, contaminated by noise. Measurements requirement include: Line layout or positioning through a GPS or otherwise; Field parameters settings, as accurate geophone spacing, shot points determination along traverse line, etc.; High precision digital recorder capable of sampling each channel at very high frequency; Reliable control of timing, sampling per channel, and the recording. Display the first - time brake intervals per channel, after each shot.

Investigations for actual design component values, as for example the minimum output voltage of a typical geophone are also required. The minimum voltage output was obtained from the set of voltage outputs obtained through digital multimeter from a number of geophones in a seismic signal detection experiment. The aim of the design is to establish consistent set of parameters that will make possible, the construction of a six channels seismic refract¯ion survey recording device. The following is the device's block diagram:

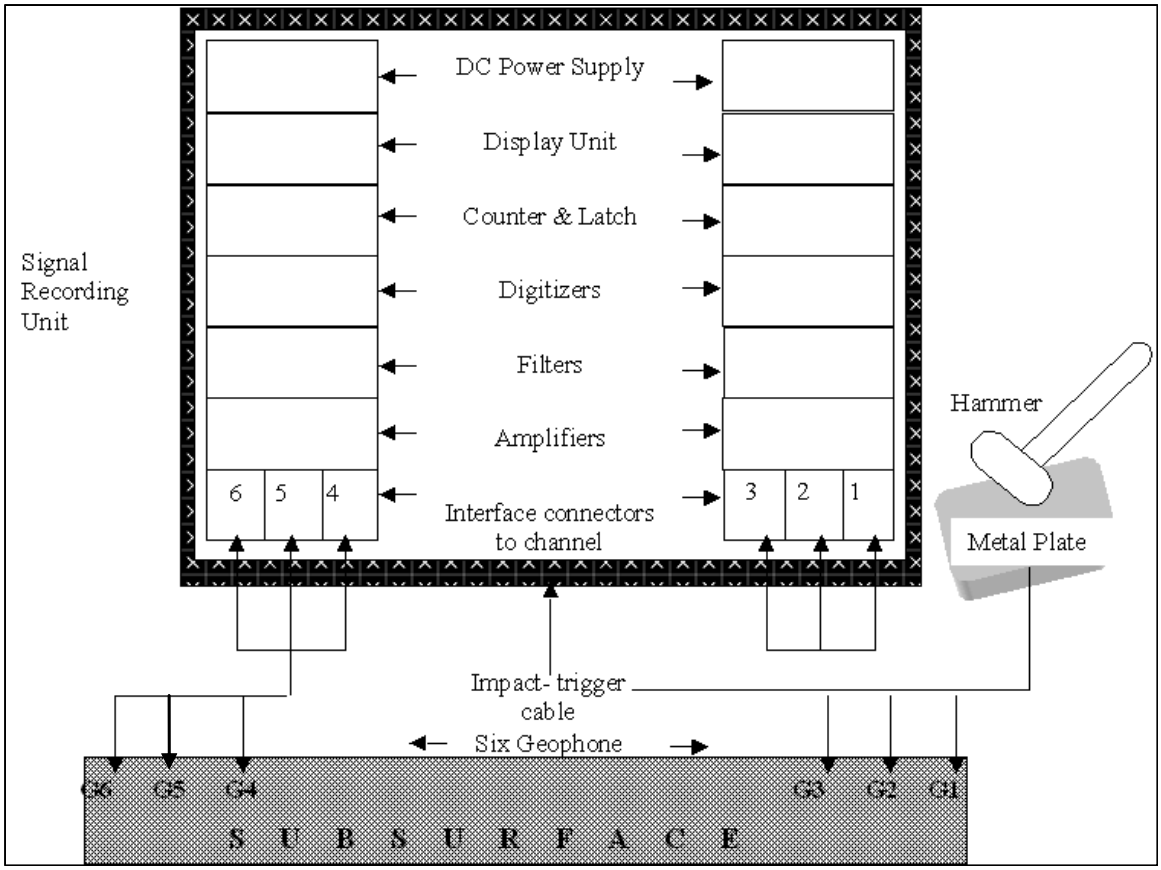

Figure 2.0: Schematic diagram of the proposed seismic signal recording device

2.1 Problem Analysis

The problem definition described by Figure 2:0 is analyzed and found to be basically: the monitoring and; detection of the first - time - brake intervals for, a generated seismic signal, transmitted from the source and later received contaminated by noise at each of the six channels. Analysis resolved the problem definition above into the following discrete steps:

i. Provide six channels of seismic signal processing
ii. Detect impact and start six counters
iii. Detect, filter, and amplify Geophone signal from each of the six channels.
iv. Convert the analog Geophone signal to digital signal
v. Scan each Geophone for seismic signal incidence and Latch it's travel time when detection occur
vi. Check if all geophones have got input value each; else keep scanning up to 120 seconds.
vii. Then display the 'detection complete' LED.
viii. Display the recorded first - time - brake interval for each channel or NO RESPONSE for any channel without signal detection during the scanning period.

Study of these discrete steps with respect to the general seismic refraction model requirements indicates that, a microcontroller solution will be most appropriate.

Microchip PIC was selected, specifically 16F877 microcontroller unit - for its capacity and availability. The following is the block diagram for construction of the equipment;

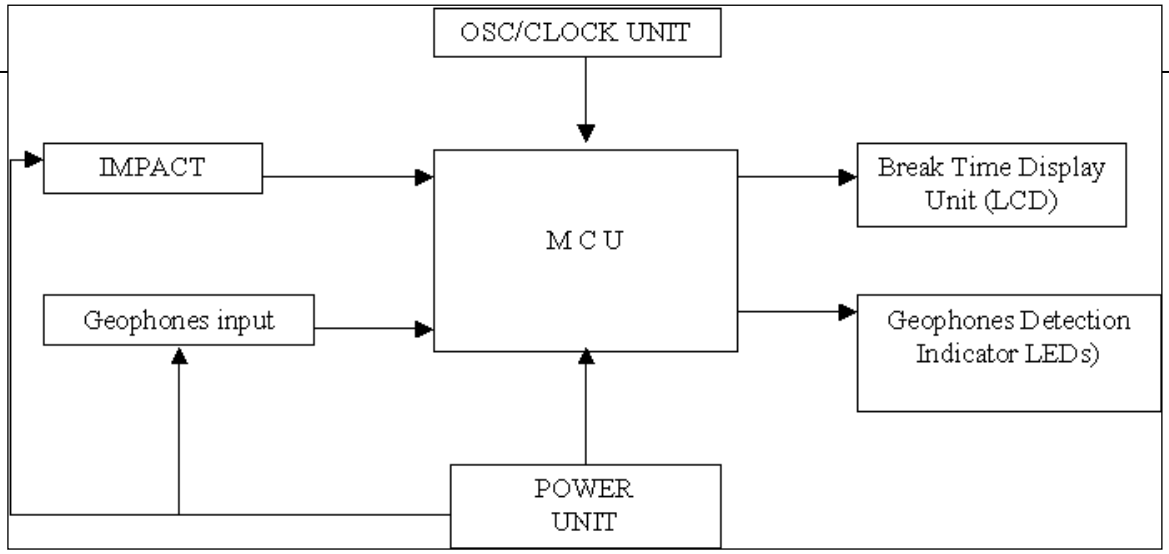

Figure 2.1: Equipment's Block Diagram.

Reset Control	1	MCLR	RB7	40	LCD E control
	2	RA0	RB6	39	LCD RW control
	3	RA1	RB5	38	LCD RS control
	4	RA2	RB4	37	
	5	RA3	RB3	36	
	6	RA4	RB2	35	
	7	RA5	RB1	34	Impact trigger
	8	RE0	RB0	33	Display control
	9	RE1	VDD	32	
	10	RE2	VSS	31	
+	11	VDD	RD7	30	Busy detecting LED
-	12	VSS	RD6	29	Detection complete LED
Crystal	13	OSC1	RD5	28	G6
OSC	14	OSC2	RD4	27	G5
	15	RC0	RC7	26	
LCD Data	16	RC1	RC6	25	LCD Date
	17	RC2	RC5	24	
	18	RC3	RC4	23	
G1	19	RD0	RD3	22	G4
G2	20	RD1	RD2	21	G3

PIC MICRO CONTROLLER [16F877]

Fig. 2.2: PIC 16F877 Pin configuration

2.2 Electronic Circuit Design

The proteus 7 professional circuit maker application was used in designing the MCU circuit- by selecting, the PIC 16f877, LCD, LEDs, resistors, capacitors and other accessories from its library manager, and linking the appropriate terminals of the

components. Other software tools used include: MPLAB - for the coding development, debugging and Hex file conversion; and EPIC - for source code upload into the PIC microcontroller. Fig. 3.3 shows the MCU circuit.

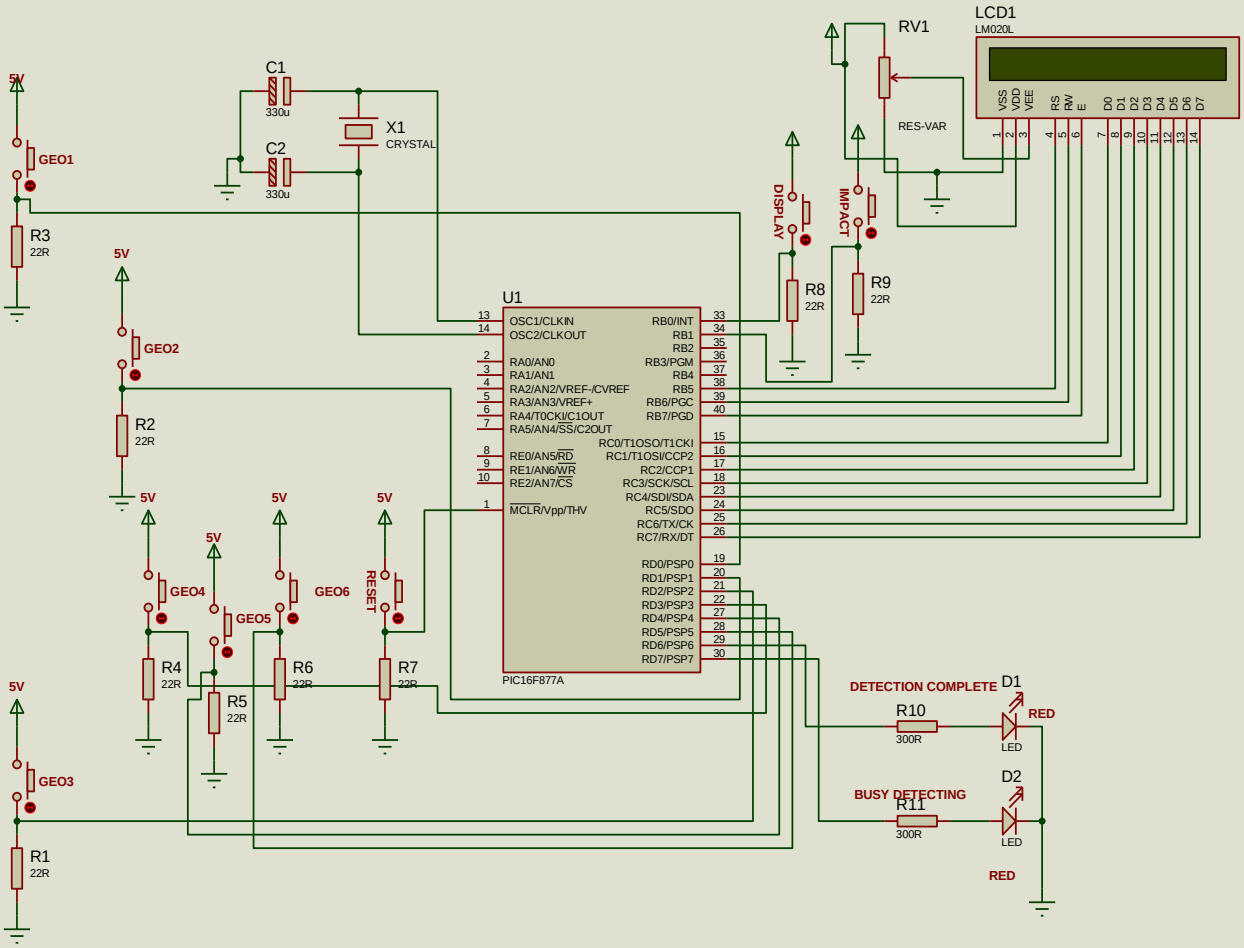

FIGURE 3.3 MICRO CONTROLLER UNIT CIRCUIT DESIGN

For function and convenience of explanation, this device is designed to have the following three units: Microcontroller unit (MCU); Peripheral Interface unit (PIU) and; the peripherals. The MCU system's input pins are RBI, RBO, RDO - RD 5 for impact triggers, display control and the six geophone inputs respective1y, while the output pins include RD7, RD6, RCO - RC7 and RB5 - RB7 which corresponds to Busy detecting LED, Detection complete LED, LCD data and LCD control respectively; illustrated by fig 2.2.

The PIU circuit objective is to converts the seismic signal obtained from each geophone to a D.C output of about 5V, which then set a bit in a designated register in the micro controller. The PIU is thus a circuit of OP Amps (LM 324), capacitors and resistors for amplification, filtering and digitization of the alternating and extremely low frequency and low voltage output of each geophone. Figure 3.4 below shows the designed PIU circuit.

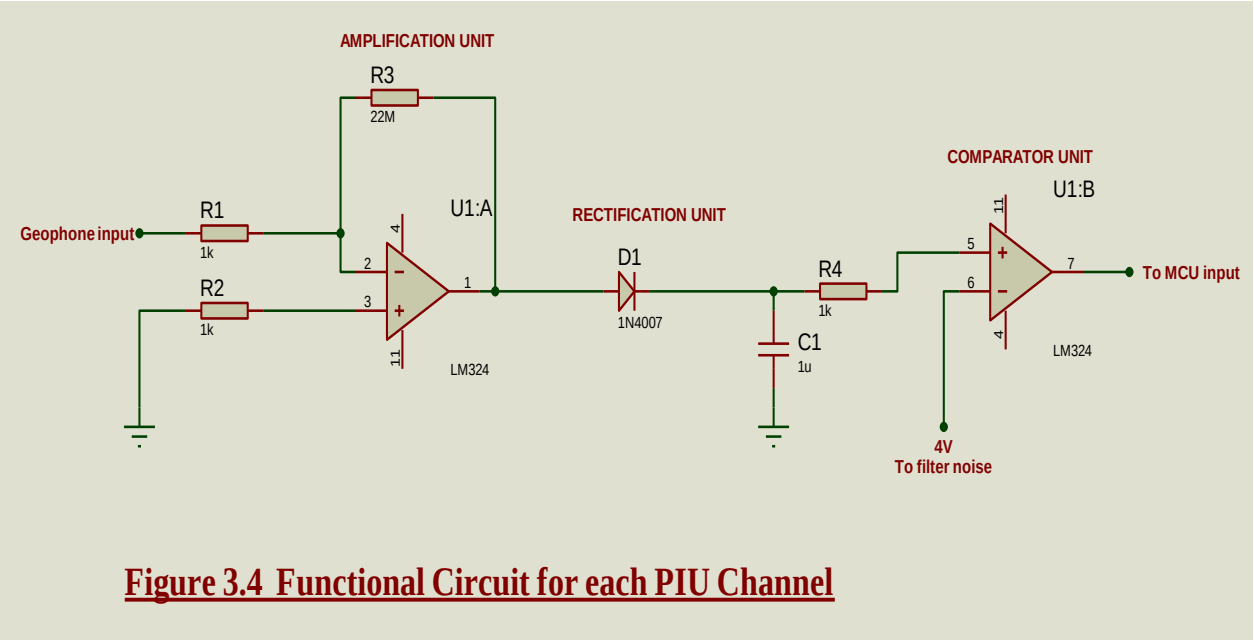

Figure 3.4 Functional Circuit for each PIU Channel

Code Development

3.0 Flow Chart

A computer system as the pic 16f877, can basically perform shifting, comparing, calculating and jumping or skipping operations. The development phases for the time brake recorder program includes: Problem definition; Analysis of the problem; Design of its algorithm; Implementation of the algorithm; Trial runs and debugging. The following is the flow chart showing the result of analyzed problem definition into graded steps:

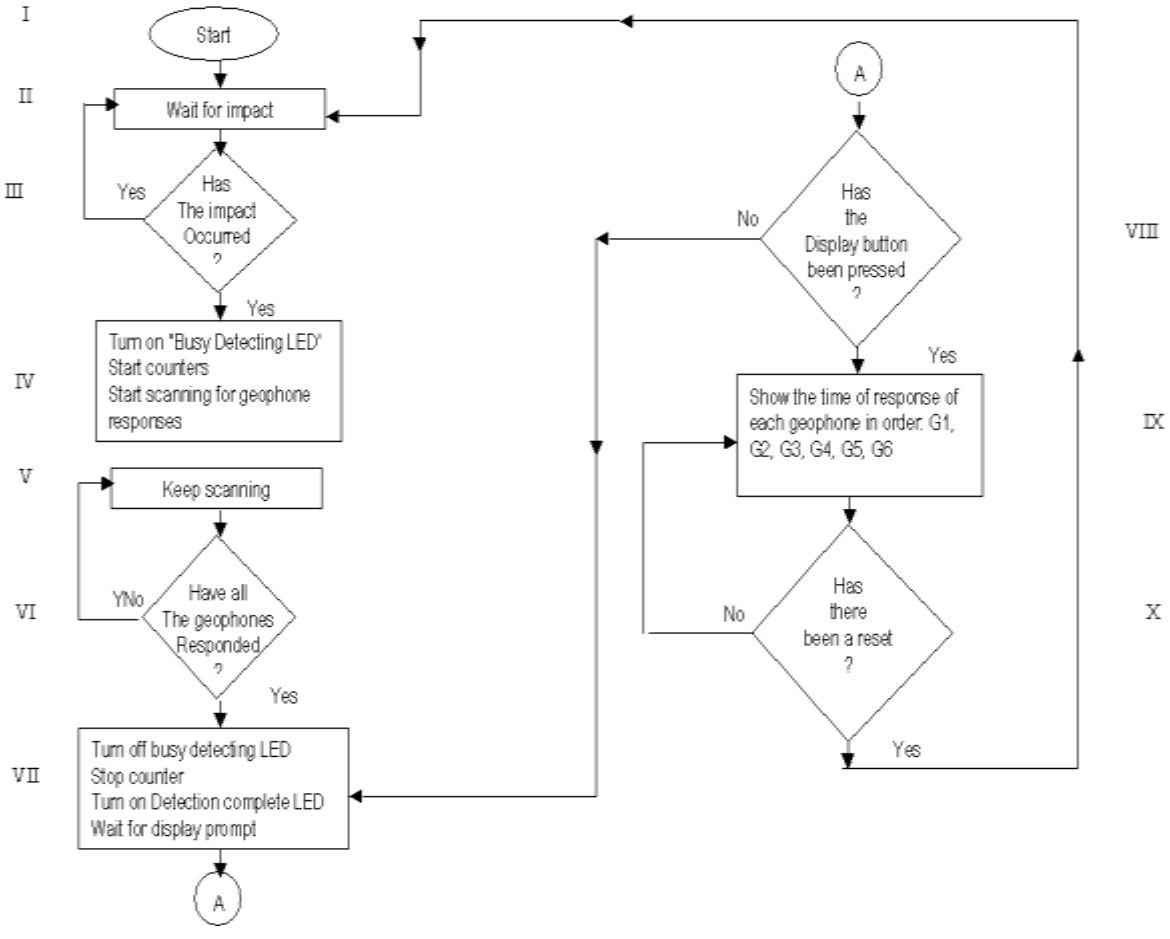

Figure 3.5: Code development flow chart

3.1 Program Modules

As a whole, the program specifies step wisely the unit operation to be performed, in identifying, locating and manipulating - data, device or mechanism needed to achieve the objective of the program. The source code, start with declarations of microcontroller configuration, invocation of the header 877.asm file and the mains. And the subroutines includes: Start-scanning; Stop-scanning; Geophone timers 1, 2, 3, 4, 5, 6; internal counters 1^{st}, 2^{nd}, 3^{rd}, 4^{th}, 5^{th} and 6^{th} digit; Delays; Displaying GI, G2, G3, G4, G5, G6 and Start.

3.2 Simulation and Code Installation

After the several rounds of debugging and few restructuring, the resulting time brake recorder program was declared error free, by the 'program editor' accompanying the Proteus 7 Professional. This is followed by uploading the error free program (included as appendix I) into the pic of the MCU circuit, and simulation carried out. The simulation runs the designed circuit correctly, including display of appropriate time intervals between clicks on the six-geophone terminals. The application is then installed into the controller, after which the chip was inserted into its socket in the constructed circuit.

Hardware Development

4.0 Structure

Based on the design, the device is made up of: Microcontroller Unit (MCU) card, Peripheral interface Unit (PIU) card, and the Peripherals.

4.1 MCU Card

The main component on this card is a 40 pin PIC 16F877. Its pin utilization involves 33 pins for input processes, including the 11 pins for LCD data and display control, through ports: B C and D, each of which has 8 pins and ports A and E of 6 and 3 pins respectively, 2 pins for the processor clocking and finally 4 pins for voltage supplies to the PIC (2Vss and $2V_{DD}$). The PIC is used in controlling all component part of this equipment, with respect to an external 4.4 MHZ crystal oscillator used in clocking the chip's processor. The processor works with memory configurations: 224KB of flash program memory, 3KB of RAM, and about 2KB of data memory. Impact pulse circuit and display switch utilize 1 pin each, while each of the six geophones also utilized one pin each on the PIC as input pins. The busy detecting and detection complete LEDs each utilized a pin on the PIC as output pins.

Approximately six hundred lines of assembly language code, uploaded into the PIC enable the control. The chip's socket is soldered into a convenient location on a Vero board, and its pins appropriately linked by soldering to the impact sensor cables, the crystal clock, each geophone input socket and their LED, the LCD, and of course, the two probe or monitor LEDs – 'busy detecting' and 'detection complete'. The impact sensor cable is a pair of 9 meters copper wire that is connected with its PIC pin, through a simple connector. The connector is on one end of the circuit, permanently screwed to a cable soldered to the PIC pin; while the 9 meters copper lines running impact signal from the

mechanical impact - trigger system may be screwed in or out, for operation and packing respectively.

Each geophone input cable was soldered into a set of connectors in the same fashion as the impact sensor cable. Each has a red or green LED soldered across the ground and the signal input cable terminals. The 16 characters per line Liquid Crystal Display - Data and Control - pins were located on the Vero board with wide-angle views of its output. It is also firmly soldered into place.

4.2 PIU Card

The PIU is a repeated dual Operational Amplifier (LM 324) circuits (fig 3.4), for amplification, filtering and digitization of geophone output. Each of these PIU circuits is directly linked to a register in the PIU through its corresponding pins as explained above. The MCU and PIU constitute the seismic energy monitoring, detection and data recording part of the device.

The immediate amplification of the Geophone signal is necessitated by the signal's extreme weakness. A feedback resistor of 22MΩ with respect to 1kΩ resistor at the non-inventing terminal delivers a gain of 23×10^3. After rectification through IN4007, the input signal is filtered through a 4V comparator voltage, to eliminate noise. The comparator output registers 0 or 1 bit at the connected MCU pin, depending on the result of the comparison test.

4.3 The Peripherals

The peripherals include the geophones, their cables, the impact - Trigger System which include the circular plate and Hammer. The impact triggered system, is made up of three pieces of copper metals organized on the circular metal plate - two of which are connected to the opposite terminals of the device's battery, and the third suspended over the other two, through thick elastic rubber - serving as pulse-switch-system, each time a hammer blow is directed on the suspended copper metal, hanging over the thick circular metal plate. The geophone transmission lines for each channel is a pair of signal and ground copper cable, running through the equipment's ground terminals and the input terminals. The thick circular metal plate and heavy hammer is used for generating seismic energy, and the plate is fabricated into circular shape to facilitate circular wave generation.

Conclusion

Observations of the equipment performance in the seismic field – tests showed:

Initially, Only G2 and G5 terminals repeatedly recorded a time during signal detection scanning on geophone terminals G1, G2, G3, G4, G5, and G6. A hammer drop adjacent to any of the six geophones blinks its LED on the MCU card. Manual tests of the MCU through the toggle switches in any manner persistently run each scanning cycle correctly.

However, when the 4V comparator voltage was reduced to about 3V, all the six geophone terminals came up, and recorded time appropriately.

This device measures the travel time of the 1st arrivals of the refracted seismic signal through each of its six channels, from which the seismic velocity and depth of the

refracting bed can be determined based on the refraction survey model's t – x graph and its analysis.

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Foremost gratitude goes to Prof. E.A. Ayolabi for conception of this project. The supervision and supports of Dr. Henry O. Boyo, such as the determination of practical filter voltage, is critical to the success of this project, and this is highly appreciated. Dr. E. O. Oyeyemi is similarly recognized. The contribution of Engr. Abdul Hakeem Morounranti is profoundly appreciated, particularly on the code development.

Reference

1. Sid Katzen: The quintessential PIC microcontroller.
2. Richer N.D.: The form and Laws of propagation of Seismic wavelet.
3. D.H. Griffiths and R.F King: Applied Geophysics for Engineers and Geologists.
4. John M. Reynold: An Introduction to Applied and Environmental Geophysics, 281 – 3.
5. Prem. V. Sharma: Environmental and Engineering Geophysics, 2002, Cambridge University Press, 126 – 158.
6. R.E. Sheriff and L.P. Geldart: Exploration Seismology, 2nd edition, 4, 226.

APPENDIX 1

```
;program for a time brake recorder.
;version: 1.0 date: 13.07.2008 mcu: pic16f877 author: Mustapha O. Adewusi
;******declarations and microcontroller configuration*******
processor 16f877
#include "p16f877.inc"
__config _cp_off & _wdt_off & _pwrte_off & _xt_osc
;*****declaration of variables*****
;header877.asm

;*****************************************************************************************************
*******
; This program can be used to determine the first time brake interval, of the response of geophones
attached to it in a seismic geophysical survey. It accommodates up to six geophones, and detects their
seismic energy impact- which is indicated by turning on a busy detecting LED; start timers; and prompts
the geophones' responses. When a particular geophone responds, it stops its timer and stores the value.
When the detection is complete, it turns off the busy detecting LED; and turns on, a detection complete
LED. When the display button is pressed, it displays the times recorded for the geophones, starting with
first geophone. The display has a capability of 0 to 999999ms.
*****************************************************************************************************
******

;equates section
                    cblock 0x20
                    point1_ms_timer
                    running_counter1
                    running_counter2
                    running_counter3
                    running_counter4
                    running_counter5
                    running_counter6
                    geophone_stop
                    geophone1_first_digit
                    geophone1_second_digit
                    geophone1_third_digit
                    geophone1_fourth_digit
                    geophone1_fifth_digit
                    geophone1_sixth_digit
                    geophone2_first_digit
                    geophone2_second_digit
                    geophone2_third_digit
                    geophone2_fourth_digit
                    geophone2_fifth_digit
                    geophone2_sixth_digit
                    geophone3_first_digit
                    geophone3_second_digit
                    geophone3_third_digit
                    geophone3_fourth_digit
                    geophone3_fifth_digit
                    geophone3_sixth_digit
                    geophone4_first_digit
                    geophone4_second_digit
                    geophone4_third_digit
                    geophone4_fourth_digit
                    geophone4_fifth_digit
                    geophone4_sixth_digit
                    geophone5_first_digit
                    geophone5_second_digit
                    geophone5_third_digit
                    geophone5_fourth_digit
                    geophone5_fifth_digit
                    geophone5_sixth_digit
                    geophone6_first_digit
                    geophone6_second_digit
                    geophone6_third_digit
                    geophone6_fourth_digit
                    geophone6_fifth_digit
                    geophone6_sixth_digit
                    lcd_delayer
                    lcd_delayer2
                    three_sec_delayer
                    point1_ms_delayer
                    ends
ader877.asm
```

```
   ;*************************************************************************
   ************************

       lcd_control               equ          portb
       lcd_data                  equ          portc
       lcd_cntl_tris             equ          trisb
       lcd_data_tris             equ          trisc
       geophone_input            equ          geophone
       geophone_input_tris       equ          trisd

       lcd_e                     equ          7
       lcd_rw                    equ          6
       lcd_rs                    equ          5
;*****************************************************
                          list   p=16f877
                          org    0x00
                          goto   start
                          org    0x04
                          goto   interp
;*****************************************************
interp                    retfie
;*****************************subroutines*************************************************
;*****************************scanning the geophones**************************************
start_scanning
                                 bsf    geophone_input,7          ;turn on busy led
                                                          ;start checking the geophones
                                 btfss  geophone_stop,1           ;has geophone 1 responded?
                                 call   geophone1_timer           ;no, keep checking geophone 1
                                 btfss  geophone_stop,2           ;has geophone 2 responded?
                                 call   geophone2_timer           ;no, keep checking geophone 2
                                 btfss  geophone_stop,3           ;has geophone 3 responded?
                                 call   geophone3_timer           ;no, keep checking geophone 3
                                 btfss  geophone_stop,4           ;has geophone 4 responded?
                                 call   geophone4_timer           ;no, keep checking geophone 4
                                 btfss  geophone_stop,5           ;has geophone 5 responded?
                                 call   geophone5_timer           ;no, keep checking geophone 5
                                 btfss  geophone_stop,6           ;has geophone 6 responded?
                                 call   geophone6_timer           ;no, keep checking geophone 6
                                 bcf    status ,z
                                 call   point1_ms_delay           ;delay for 100us
                                 incf   point1_ms_timer,1         ;after100us,increase this count
                                 movlw  .10
                                 subwf  point1_ms_timer,0
                                 btfsc  status,z                  ;have you counted for 1ms?
                                 call   first_digit               ;increase the units digit
                                 movlw  .10
                                 subwf  running_counter1,0        ;is units digit up to 10?
                                 btfsc  status,z
                                 call   second_digit              ;yes, increase page 2
                                 bcf    status,z                  ;no, keep counting
                                 movlw  .10
                                 subwf  running_counter2,0        ;is tens digit up to 10?
                                 btfsc  status,z
                                 call   third_digit               ;yes, increase hundred digit
                                 bcf    status,z                  ;no, keep counting
                                 movlw  .10
                                 subwf  running_counter3,0        ;is hundreds digit up to 10?
                                 btfsc  status,z
                                 call   fourth_digit              ;yes, increase thousands digit
                                 bcf    status,z                  ;no, keep counting
                                 movlw  .10
                                 subwf  running_counter4,0        ;is thousand digit up to 10?
                                 btfsc status,z
                                 call   fifth_digit               ;yes,  increase  hundred  thous
                          digit
                                 bcf    status,z                  ;no, keep counting
                                 movlw  .10
                                 subwf  running_counter5,0        ;is thousand digit up to 10?
                                 btfsc  status,z
                                 call   sixth_digit               ;yes, increase ten thousand dig
                                 bcf    status,z                  ;no, keep counting
                                 btfss  geophone_stop,1           ;has geophone 1 responded?
                                 goto   start_scanning            ;no, keep checking
                                 btfss  geophone_stop,2           ;has geophone 2 responded?
                                 goto   start_scanning            ;no, keep checking
                          btfss  geophone_stop,3           ;has geophone 3 responded?
```

```
                        goto   start_scanning      ;no, keep checking
                        btfss  geophone_stop,4     ;has geophone 4 responded?
                        goto   start_scanning      ;no, keep checking
                        btfss  geophone_stop,5     ;has geophone 5 responded?
                        goto   start_scanning      ;no, keep checking
                        btfss  geophone_stop,6     ;has geophone 6 responded?
                        goto   start_scanning      ;no, keep checking
                        return                     ;yes, stop checking
stop_scanning
                        bcf    geophone_input,7    ;turn off busy led
                        bsf    geophone_input,6    ;turn on detection complete led
                        btfss  lcd_control,0       ;are you ready to display?
                        goto   stop_scanning
                        return
;************************geophone timers***********************
geophone1_timer
                    btfss        geophone_input,0
                        return
                        bsf          geophone_stop, 1          ;set geophone 1 stopper
                        movf         running_counter1, 0       ;latch   the   timers
                    geophone 1
                        movwf        geophone1_first_digit
                        movf         running_counter2,0
                        movwf        geophone1_second_digit
                        movf         running_counter3,0
                        movwf        geophone1_third_digit
                        movf         running_counter4,0
                        movwf        geophone1_fourth_digit
                        movf         running_counter5,0
                        movwf        geophone1_fifth_digit
                        movf         running_counter6,0
                        movwf        geophone1_sixth_digit
                        bcf          status,z
                        return
      geophone2_timer
                        btfss        geophone,1
                        return
                        bsf          geophone_stop,2           ;set geophone 2 stopper
                        movf         running_counter1, 0       ;latch   the   timers
                    geophone 2
                        movwf        geophone2_first_digit
                        movf         running_counter2,0
                        movwf        geophone2_second_digit
                        movf         running_counter3,0
                        movwf        geophone2_third_digit
                        movf         running_counter4,0
                        movwf        geophone2_fourth_digit
                        movf         running_counter5,0
                        movwf        geophone2_fifth_digit
                        movf         running_counter6,0
                        movwf        geophone2_sixth_digit
                        bcf          status,z
                        return
      geophone3_timer
                        btfss        geophone_input,2
                        return
                        bsf          geophone_stop,3           ;set geophone 3 stopper
                        movf         running_counter1, 0       ;latch   the   timers
                    geophone 3
                        movwf        geophone3_first_digit
                        movf         running_counter2,0
                        movwf        geophone3_second_digit
                        movf         running_counter3,0
                        movwf        geophone3_third_digit
                        movf         running_counter4,0
                        movwf        geophone3_fourth_digit
                        movf         running_counter5,0
                        movwf        geophone3_fifth_digit
                        movf         running_counter6,0
                        movwf        geophone3_sixth_digit
                        bcf          status,z
                        return
      geophone4_timer
```

```
                        bsf             geophone_stop,4             ;set geophone 4 stopper
                        movf            running_counter1, 0         ;latch   the   timers   of
                    geophone 4
                        movwf           geophone4_first_digit
                        movf            running_counter2,0
                        movwf           geophone4_second_digit
                        movf            running_counter3,0
                        movwf           geophone4_third_digit
                        movf            running_counter4,0
                        movwf           geophone4_fourth_digit
                        movf            running_counter5,0
                        movwf           geophone4_fifth_digit
                        movf            running_counter6,0
                        movwf           geophone4_sixth_digit
                        bcf             status,z
                        return
geophone5_timer
                        btfss           geophone_input,4
                        return
                        bsf             geophone_stop,5             ;set geophone 5 stopper
                        movf            running_counter1, 0         ;latch   the   timers   of
                    geophone 5
                        movwf           geophone5_first_digit
                        movf            running_counter2,0
                        movwf           geophone5_second_digit
                        movf            running_counter3,0
                        movwf           geophone5_third_digit
                        movf            running_counter4,0
                        movwf           geophone5_fourth_digit
                        movf            running_counter5,0
                        movwf           geophone5_fifth_digit
                        movf            running_counter6,0
                        movwf           geophone5_sixth_digit
                        bcf             status,z
                        return
geophone6_timer
                        btfss           geophone_input,5
                        return
                        bsf             geophone_stop,6             ;set geophone 6 stopper
                        movf            running_counter1, 0         ;latch   the   timers   of
                    geophone 6
                        movwf           geophone6_first_digit
                        movf            running_counter2,0
                        movwf           geophone6_second_digit
                        movf            running_counter3,0
                        movwf           geophone6_third_digit
                        movf            running_counter4,0
                        movwf           geophone6_fourth_digit
                        movf            running_counter5,0
                        movwf           geophone6_fifth_digit
                        movf            running_counter6,0
                        movwf           geophone6_sixth_digit
                        bcf             status,z
                        return
;*****************************internal counters*********************************************
first_digit
                        clrf            point1_ms_timer             ;set 100us counter to zero
                        incf            running_counter1,1          ;increment    the    units
                    counter
                        bcf             status,z
                        return
second_digit
                        clrf            running_counter1            ;decrement    the    units
                    counter
                        incf            running_counter2,1          ;increment    the    tens
                    counter
                        bcf             status,z
                        return
third_digit
                        clrf            running_counter2            ;decrement    the    tens
                    counter
                        incf            running_counter3,1          ;increment   the   hundreds
                    counter
                        bcf             status,z
                        return
fourth_digit
                        clrf            running_counter3            :decrement   the   hundreds
```

```
fifth_digit
                        clrf    running_counter4        ;decrement the thousands counter
                        incf    running_counter5,1      ;increment   the   ten   thousand
                counter
                        bcf     status,z
                        return
sixth_digit
                        clrf    running_counter5        ;decrement   the   ten   thousand
                counter
                        incf    running_counter6,1      ;increment  the  hundred  thousand
                counter
                        bcf     status,z
                        return
;*********************************delays**************************
point1_ms_delay
                        movlw   .166                    ;100us delay
                        movwf   point1_ms_delayer
                        decfsz  point1_ms_delayer,1
                        goto    $-1
                        return
lcd_delay                               ;20ms   delay   for   lcd   to   process   command
received

                        movlw   .166
                        movwf   lcd_delayer
                        movlw   .200
                        movwf   lcd_delayer2
                        decfsz  lcd_delayer2,1
                        goto    $-1
                        decfsz  lcd_delayer,1
                        goto    $-5
                        return
threesec                                ;three seconds hold for lcd outputs
                        movlw   .150
                        movwf   three_sec_delayer
                        call    lcd_delay
                        decfsz  three_sec_delayer,1
                        goto    $-2
                        return
table
                        addwf   pcl,1
                        retlw   0x30                    ;0
                        retlw   0x31                    ;1
                        retlw   0x32                    ;2
                        retlw   0x33                    ;3
                        retlw   0x34                    ;4
                        retlw   0x35                    ;5
                        retlw   0x36                    ;6
                        retlw   0x37                    ;7
                        retlw   0x38                    ;8
                        retlw   0x39                    ;9
                        return
;****************************displaying the times for the geophones****************
display
                clrf    lcd_control
                clrf    lcd_data
                call    lcd_delay
                bsf     status,rp0
                movlw   0x00
                movwf   lcd_data_tris
                movwf   lcd_cntl_tris
                bcf     status,z
;*********************************setting display format**********************************
                bcf     status,rp0
                bsf     lcd_control,lcd_e
                movlw   0x38                    ;8 bits and two lines
                call    write_command
                movlw   0x0e                    ;clear the memory
                call    write_command
                movlw   0x06                    ;no cursor
                call    write_command
;*********************************geophone1 display**********************************

                movlw   0x47                    ;g
                call    write_data
                movlw   0x31                    ;1
                call    write_data
```

```
                movlw       0x20                        ;
                call        write_data
                movlw       0x20                        ;
                call        write_data
                movf        geophone1_sixth_digit,0     ;hundred thousands digit of geophone 1
        time
                call        table
                call        write_data
                movf        geophone1_fifth_digit,0     ;ten thousands digit of geophone 1 time
                call        table
                call        write_data
                movf        geophone1_fourth_digit,0    ;thousands digit of geophone 1 time
                call        table
                call        write_data
                movf        geophone1_third_digit,0     ;hundreds digit of geophone 1 time
                call        table
                call        write_data
                movf        geophone1_second_digit,0    ;tens digit of geophone 1 time
                call        table
                call        write_data
                movf        geophone1_first_digit,0     ;unit digit of geophone 1 time
                call        table
                call        write_data
                movlw       0x6d                        ;m
                call        write_data
                movlw       0x73                        ;s
                call        write_data
                movlw       0x20                        ;
                call        write_data
                movlw       0x20                        ;
                call        write_data
                movlw       0x20                        ;
                call        write_data
                movlw       0x20                        ;
                call        write_data
                movlw       threesec
                movlw       0x02                        ;return home
                call        write_command
;************************geophone2 display*************************************
                movlw       0x47                        ;g
                call        write_data
                movlw       0x32                        ;2
                call        write_data
                movlw       0x20                        ;
                call        write_data
                movlw       0x20                        ;
                call        write_data
                movf        geophone2_sixth_digit,0     ;hundred thousands digit of geophone 2
        time
                call        table
                call        write_data
                movf        geophone2_fifth_digit,0     ;ten thousands digit of geophone 2 time
                call        table
                call        write_data
                movf        geophone2_fourth_digit,0    ;thousands digit of geophone 2 time
                call        table
                call        write_data
                movf        geophone2_third_digit,0     ;hundreds digit of geophone 2 time
                call        table
                call        write_data
                movf        geophone2_second_digit,0    ;tens digit of geophone 2 time
                call        table
                call        write_data
                movf        geophone2_first_digit,0     ;unit digit of geophone 2 time
                call        table
                call        write_data
                movlw       0x6d                        ;m
                call        write_data
                movlw       0x73                        ;s
                call        write_data
                movlw       0x20                        ;
                call        write_data
                movlw       0x20                        ;
                call        write_data
```

```
                movlw       0x20                    ;
                call        write_data
                movlw       0x20                    ;
                call        write_data
                call        threesec
                movlw       0x02                    ;return home
                call        write_command
;*************************geophone3 display*************************************
                movlw       0x47                    ;g
                call        write_data
                movlw       0x33                    ;3
                call        write_data
                movlw       0x20                    ;
                call        write_data
                movlw       0x20                    ;
                call        write_data
                movf        geophone3_sixth_digit,0 ;hundred thousands digit of geophone 3
        time
                call        table
                call        write_data
                movf        geophone3_fifth_digit,0 ;ten thousands digit of geophone 3 time
                call        table
                call        write_data
                movf        geophone3_fourth_digit,0 ;thousands digit of geophone 3 time
                call        table
                call        write_data
                movf        geophone3_third_digit,0 ;hundreds digit of geophone 3 time
                call        table
                call        write_data
                movf        geophone3_second_digit,0 ;tens digit of geophone 3 time
                call        table
                call        write_data
                movf        geophone3_first_digit,0 ;unit digit of geophone 3 time
                call        table
                call        write_data
                movlw       0x6d                    ;m
                call        write_data
                movlw       0x73                    ;s
                call        write_data
                movlw       0x20                    ;
                call        write_data
                movlw       0x20                    ;
                call        write_data
                movlw       0x20                    ;
                call        write_data
                movlw       0x20                    ;
                call        write_data
                call        threesec
                movlw       0x02                    ;return home
                call        write_command
;*************************geophone4 display*************************************
                movlw       0x47                    ;g
                call        write_data
                movlw       0x34                    ;4
                call        write_data
                movlw       0x20                    ;
                call        write_data
                movlw       0x20                    ;
                call        write_data
                movf        geophone4_sixth_digit,0 ;hundred thousands digit of geophone 4
        time
                call        table
                call        write_data
                movf        geophone4_fifth_digit,0 ;ten thousands digit of geophone 4 time
                call        table
                call        write_data
                movf        geophone4_fourth_digit,0 ;thousands digit of geophone 4 time
                call        table
                call        write_data
                movf        geophone4_third_digit,0 ;hundreds digit of geophone 4 time
                call        table
                call        write_data
                movf        geophone4_second_digit,0 ;tens digit of geophone 4 time
                call        table
```

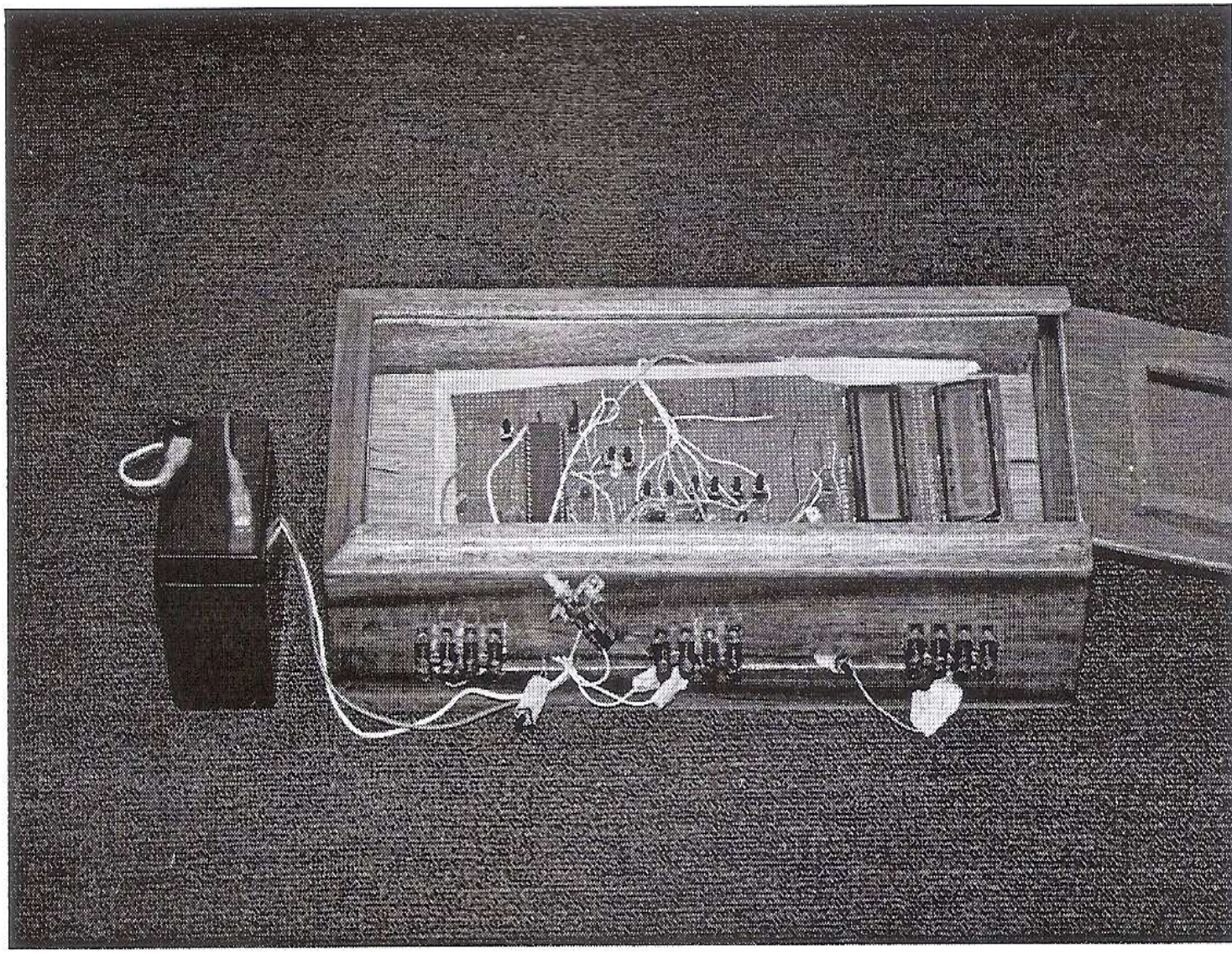
```
                call            write_data
                movf            geophone4_first_digit,0    ;unit digit of geophone 4 time
                call            table
                call            write_data
                movlw           0x6d                       ;m
                call            write_data
                movlw           0x73                       ;s
                call            write_data
                movlw           0x20                       ;
                call            write_data
                movlw           0x20                       ;
                call            write_data
                movlw           0x20                       ;
                call            write_data
                movlw           0x20                       ;
                call            write_data
                call            threesec
                movlw           0x02                       ;return home
                call            write_command
;*************************geophone5 display*************************************
                movlw           0x47                       ;g
                call            write_data
                movlw           0x35                       ;5
                call            write_data
                movlw           0x20                       ;
                call            write_data
                movlw           0x20                       ;
                call            write_data
                movf            geophone5_sixth_digit,0    ;hundred thousands digit of geophone 5
        time
                call            table
                call            write_data
                movf            geophone5_fifth_digit,0    ;ten thousands digit of geophone 5 time
                call            table
                call            write_data
                movf            geophone5_fourth_digit,0   ;thousands digit of geophone 5 time
                call            table
                call            write_data
                movf            geophone5_third_digit,0    ;hundreds digit of geophone 5 time
                call            table
                call            write_data
                movf            geophone5_second_digit,0   ;tens digit of geophone 5 time
                call            table
                call            write_data
                movf            geophone5_first_digit,0    ;unit digit of geophone 5 time
                call            table
                call            write_data
                movlw           0x6d                       ;m
                call            write_data
                movlw           0x73                       ;s
                call            write_data
                movlw           0x20                       ;
                call            write_data
                movlw           0x20                       ;
                call            write_data
                movlw           0x20                       ;
                call            write_data
                movlw           0x20                       ;
                call            write_data
                call            threesec
                movlw           0x02                       ;return home
                call            write_command
;*************************geophone6 display*************************************
                movlw           0x47                       ;g
                call            write_data
                movlw           0x36                       ;6
                call            write_data
                movlw           0x20                       ;
                call            write_data
                movlw           0x20                       ;
                call            write_data
                movf            geophone6_sixth_digit,0    ;hundred thousands digit of geophone 6
        time
                call            table
```

```
                call            write_data
                movf            geophone6_fifth_digit,0    ;ten thousands digit of geophone 6 time
                call            table
                call            write_data
                movf            geophone6_fourth_digit,0   ;thousands digit of geophone 6 time
                call            table
                call            write_data
                movf            geophone6_third_digit,0    ;00hundreds digit of geophone 6 time
                call            table
                call            write_data
                movf            geophone6_second_digit,0   ;tens digit of geophone 6 time
                call            table
                call            write_data
                movf            geophone6_first_digit,0    ;unit digit of geophone 6 time
                call            table
                call            write_data
                movlw           0x6d                       ;m
                call            write_data
                movlw           0x73                       ;s
                call            write_data
                movlw           0x20                       ;
                call            write_data
                movlw           0x20                       ;
                call            write_data
                movlw           0x20                       ;
                call            write_data
                movlw           0x20                       ;
                call            write_data
                call            threesec
                movlw           0x02                       ;return home
                call            write_command
                btfss           portb,1
                goto            display
                return
;************************lcd commands*****************************************
write_data                                                 ;sending data to the lcd
                    bsf             lcd_control,lcd_rs
                    bcf             lcd_control,lcd_rw
                    bsf             lcd_control,lcd_e
                    movwf           lcd_data
                    call            lcd_delay
                    bcf             lcd_control,lcd_e
                    return
write_command                                              ;sending instructions to the lcd
                    bcf             lcd_control,lcd_rs
                    bcf             lcd_control,lcd_rw
                    bsf             lcd_control,lcd_e
                    movwf           lcd_data
                    call            lcd_delay
                    bcf             lcd_control,lcd_e
                    return
;*********************************initialising*************************************
start                                                      ;initializing all registers
                    clrf            running_counter1
                    clrf            running_counter2
                    clrf            running_counter3
                    clrf            running_counter4
                    clrf            running_counter5
                    clrf            lcd_delayer
                    clrf            lcd_delayer2
                    clrf            three_sec_delayer
                    clrf            point1_ms_delayer2
                    clrf            point1_ms_delayer3
                    clrf            point1_ms_timer
                    clrf            geophone1_first_digit
                    clrf            geophone1_second_digit
                    clrf            geophone1_third_digit
                    clrf            geophone1_fourth_digit
                    clrf            geophone1_fifth_digit
                    clrf            geophone2_first_digit
                    clrf            geophone2_second_digit
                    clrf            geophone2_third_digit
```

```
                    clrf        geophone2_fourth_digit
                    clrf        geophone2_fifth_digit
                    clrf        geophone3_first_digit
                    clrf        geophone3_second_digit
                    clrf        geophone3_third_digit
                    clrf        geophone3_fourth_digit
                    clrf        geophone3_fifth_digit
                    clrf        geophone4_first_digit
                    clrf        geophone4_second_digit
                    clrf        geophone4_third_digit
                    clrf        geophone4_fourth_digit
                    clrf        geophone4_fifth_digit
                    clrf        geophone5_first_digit
                    clrf        geophone5_second_digit
                    clrf        geophone5_third_digit
                    clrf        geophone5_fourth_digit
                    clrf        geophone5_fifth_digit
                    clrf        geophone6_first_digit
                    clrf        geophone6_second_digit
                    clrf        geophone6_third_digit
                    clrf        geophone6_fourth_digit
                    clrf        geophone6_fifth_digit
                    clrf        geophone_stop
                    clrf        status
                    clrf        lcd_control
                    clrf        lcd_data
                    clrf        geophone_input
                    bsf         status,rp0
                    movlw       0x03
                    movwf       lcd_cntl_tris           ;pins  0-1  are  inputs,  2-7  are
              outputs
                    movlw       0x00
                    movwf       lcd_data_tris           ;all outputs
                    movlw       0x3f
                    movwf       geophone_input_tris     ;all inputs except pin 6 and 7

                    bcf         status,rp0
;*********************************running*************************************
Main                                                    ;start the recorder
                    btfss       lcd_control, 1          ;check for impact
                    goto        $-1
                    call        start_scanning
                    call        stop_scanning
                    call        display                 ;start scanning geophones
                    end
```

Appendix 2



Photograph of the 6-Channels Seismograph